JOURNAL OF DAIRY SCIENCE

DECEMBER, 1957

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Testicular Size and Production of Spermatozoa
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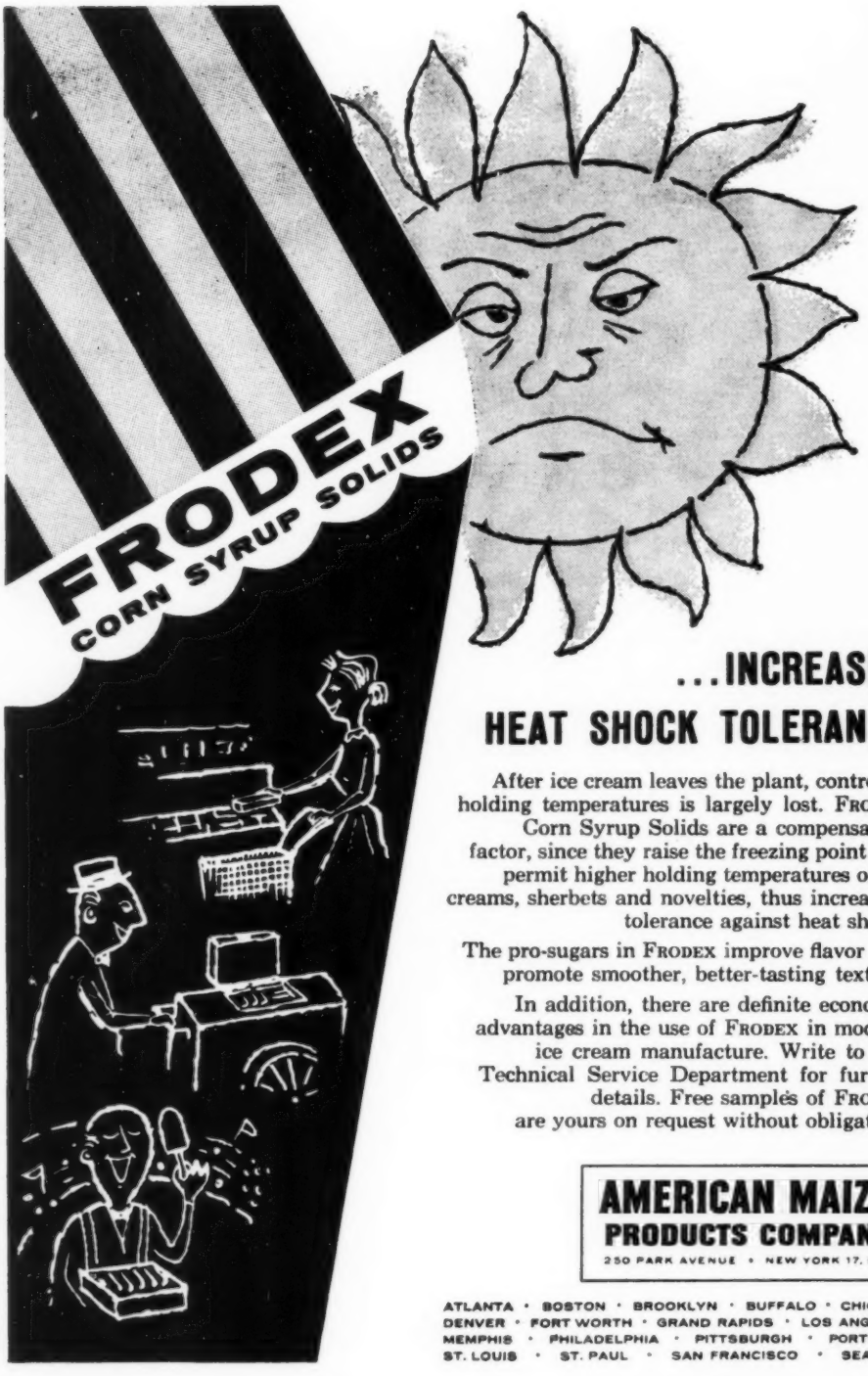
AMERICAN DAIRY SCIENCE ASSOCIATION



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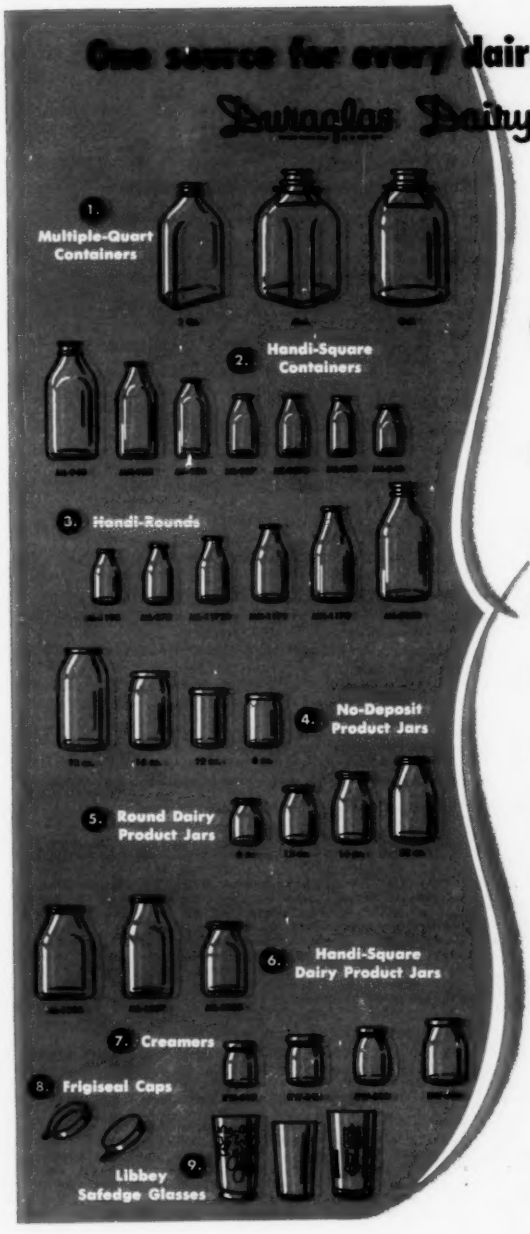

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VOLUME XL December, 1957 NUMBER 12

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PEOPLE and EVENTS
in the Dairy Science World

P. M. Brandt of Oregon Retires

P. M. BRANDT, after more than 40 years of distinguished service, has retired as head of the Dept. of Dairying at Oregon State College, Corvallis.

P. M. Brandt

Born, reared, and educated in Missouri, Prof. Brandt served on the Univ. of Missouri Staff from 1911 to 1917, leaving that school as assistant to the Dean of Agriculture to become head of the Dept. of Dairying at Oregon. He served at Oregon continuously from 1917 until his retirement in 1957.

He held many positions in industry groups, including the Missouri State Dairymens Association, the Oregon Dairymens Association, the Oregon Dairy Council, and the Oregon Products Commission.

A highlight of his administration was the construction of Withycombe Hall, completed in 1952. This building houses the Depts. of Dairying and Animal Husbandry and includes a modern milk processing plant and many research laboratories.

Long active in community affairs, Prof. Brandt served on the Corvallis City council, 1924-1933, and was Mayor of the city in 1933 and 1934. He was appointed to the State Legislative Committee on Retirement and Compensation which was instrumental in the enactment of the present retirement act for state employees in Oregon.

Program
1958 Meeting
Southern Section
American Dairy Science Association
Little Rock, Arkansas

Monday, February 3

8:30-11:00 A.M. K. M. Autrey, Chairman.

1. A study of the relationship between A.O.A.C., Mojonnier, and Watson lactometer determinations of total solids in raw whole milk. N. R. THOMPSON, W. K. STONE, AND G. C. GRAF, Virginia Agricultural Experiment Station.

2. The influence of feed upon the yield and composition of Milk. I. I. PETERS, R.R. HARRIS, AND C. A. MULAY, Texas Agricultural Experiment Station.

3. The effect of the dairy herd ration upon the suceptibility of milk to induced hydrolytic rancidity. W. B. GILMORE, J. J. WILLINGHAM, AND K. L. NEELEY. Texas Technological College.

4. The effect of various factors on the incidence and intensity of rancid flavor in raw milk handled in bulk tanks. R. L. VON GUNTEN, P. E. JOHNSON, AND H. C. OLSON, Oklahoma State University.

5. The influence of rapid cooling on the development of a rancid flavor in milk produced by bulk systems. P. E. JOHNSON AND R. L. VON GUNTEN, Oklahoma State University.

6. Our future job. C. G. CUSHMAN, Clemson Agricultural College.

7. How grain feeding of calves on pasture affects forage intake, digestibility, and rate of growth. J. W. RUST, L. D. BROWN, AND D. M. SEATH, Kentucky Agricultural Experiment Station.

8. A preliminary analysis: birthweights of Holstein and Jersey female calves born in southern Louisiana. E. J. STONE, E. B. MORGAN, J. E. JOHNSTON, AND J. B. FRYE, JR., Louisiana State University.

11:00-12:00 A.M. General Session of Association of Southern Agricultural Workers

1:30-2:30 P.M. J. T. Miles, Chairman

9. Relationship between estrogenic potency of soybean and cottonseed meals and lactation response. G. E. HAWKINS AND K. M. AUTREY, Alabama Agricultural Experiment Station.

10. Estrogenic potency of freshly cut forages in relation to their value as sources of nutrients for milking cows. G. E. HAWKINS AND K. M. AUTREY, Alabama Agricultural Experiment Station.

11. Utilization by dairy cows of intravenously administered carotene. J. D. SCHUH, W. D. GALLUP, S. D. MUSGRAVE, AND C. L. NORTON, Oklahoma State University.

12. Comparative study of the effects of intravenous and nasal administration of the letdown hormone on residual milk. HIROO YAMAMOTO, Loyola University.

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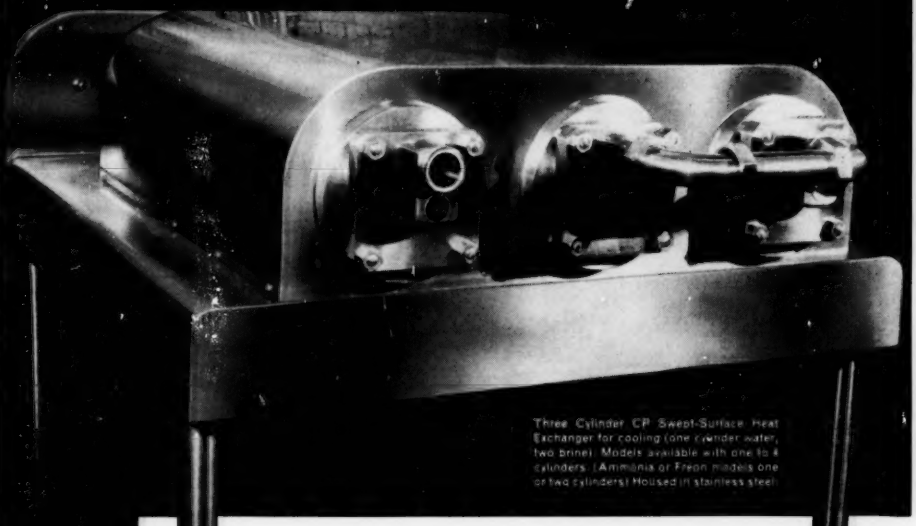

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2:30-4:30 P.M. Symposium. Building Public Relations in the Dairy Industry by Solving Today the Problems of Tomorrow. H. B. Henderson, Moderator.

Statement of the problem. J. W. Pou, North Carolina State College.

Present status of research in the field of dietary fats. D. H. Jacobson, American Dairy Association. Discussion leader: Paul Day, University of Arkansas.

Present status of the problem of radiation fall-out. B. F. Trum, Atomic Energy Commission. Discussion leader: G. K. Davis, University of Florida.

Our responsibility as dairy workers. I. W. Rupel, Texas Agricultural Experiment Station.

Tuesday, February 4

8:30-11:00 A.M. J. W. Pou, Chairman

13. The growth of Jersey and Sindhi-Jersey cross-bred heifers at the Iberia Livestock Station. J. L. Fletcher, S. L. Cathcart, and C. E. Hyde, USDA. Iberia Livestock Dairy Station.

14. Effect of various cooling practices on semen production. T. E. Patrick, H. C. Kellgren, Cecil Branton, and J. E. Johnston, Louisiana State University.

15. Homologous vs. non-homologous nutrient systems for the culture of bovine testicular tissues. M. A. Brown, Texas Agricultural Experiment Station.

16. Some observations on reproductive performances of dairy cattle in Louisiana. J. G. Hall, C. Branton, E. J. Stone, R. B. Lank, and J. B. Frye, Jr., Louisiana State University.

17. A study of factors affecting the number of cows bred artificially. Durward Olds, Ellis Mullins, and D. M. Seath. Kentucky Agricultural Experiment Station.

10:00-11:00 A.M. Sectional Business Meeting, K. M. Autrey, Presiding

11:00-12:00 A.M. General Session, Association of Southern Agricultural Workers

1:30-4:30 P.M. Dairy Production joint meeting with Animal Husbandry Section

Symposium: The Effect of Heat on Animal Performance. *Moderator*: R. W. Phillips, Foreign Agricultural Service, USDA; *Physiology*: R. E. McDowell, USDA; *Reproduction*: L. E. Ulberg, North Carolina State College; *Milk Production*: J. E. Johnston, Louisiana State University; *Growth and Fattening*: E. L. Warwick, USDA; *Building and Facilities*: T. E. Bond, University of California; *Breeding*: R. R. Shrode, Texas A & M.

1:30-4:30 P.M. Dairy Manufacturing, H. C. Olson, Chairman

18. The manufacture of Cheddar cheese from pasteurized homogenized milk. I. I. Peters,

C. A. MULAY, AND G. L. DALTON, Texas Agricultural Experiment Station.

19. A study of selected chemical and physical properties of high solids cultured milks. JOHN JAYNES, E. R. JARMAN, AND J. J. WILLINGHAM, Texas Technological College.

20. The influence of frequency of transfer and of incubation period on the activity of lactic cultures. H. C. OLSON, Oklahoma State University.

21. A procedure for evaluating cottage cheese type nonfat dry milk. W. K. STONE AND P. M. LARGE, Virginia Agricultural Experiment Station.

22. Propionic acid prolongs shelf life of cottage cheese. A. J. GELPI, JR. AND L. L. RUSOFF, Louisiana State University.

23. Relationship of bacterial numbers and types of spoilage of pasteurized milk held at certain refrigeration temperatures. W. E. GLENN, Kentucky Agricultural Experiment Station.

24. Study of the phosphatase test. P. J. MAGNINO, JR. AND J. B. MICKLE, Oklahoma State University.

25. Thresholds in judging rancid milk. A. V. MOORE, Texas Agricultural Experiment Station.

26. Salaries of dairy manufacturing graduates. H. B. HENDERSON, University of Georgia.

6:30 P.M. Banquet and Honors Program

Wednesday, February 5

8:30-12:00 A.M. J. B. Frye, Jr., Chairman

27. Some factors influencing the time required for dairy cows to eat concentrates. D. V. BOSTAIN AND O. T. STALLCUP, University of Arkansas.

28. A comparison of two systems of feeding roughage to dairy cattle. A. V. DAVIS, North Louisiana Experiment Station, Calhoun, Louisiana.

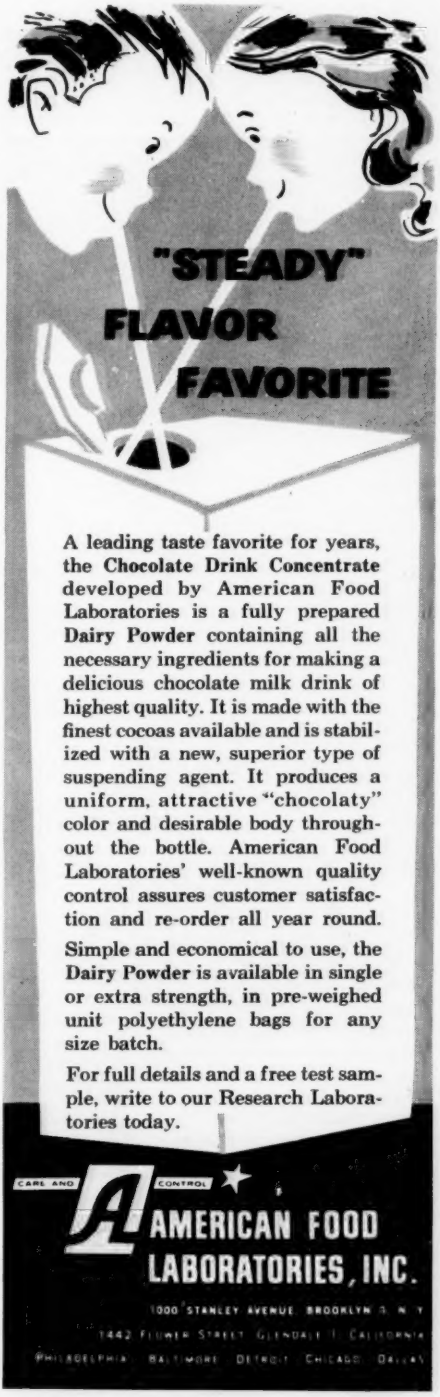
29. Substituting concentrates for corn silage in drouth years. W. A. KING, Clemson Agricultural College.

30. The effect of milk to grain ratio on the milk production of dairy cattle when the roughage fed is: (1) hay and silage, (2) silage, (3) small grain winter pasture, (4) cattail millet pasture, and (5) bahiagrass pasture. H. D. ELLZEY, Southeast Louisiana Experiment Station, Franklinton, Louisiana.

31. A Johnson grass-sorghum hybrid, coastal bermuda grass, and tift sudan grass as pastures for milk production. W. D. CRAFT, J. R. OWEN, W. C. COWSERT, AND J. T. MILES, Mississippi Agricultural Experiment Station.

32. Comparison of Georgia number one hybrid millet and Piper sudan for lactating dairy cows. L. J. BOYD AND J. B. MCLAREN, Tennessee Agricultural Experiment Station.

33. The feeding value of oat silage cut at two stages of maturity and preserved with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sodium metabisulfite or ground snap corn. L. R. SISK, M. E. MCCULLOUGH, AND O. E. SELL. Georgia Experiment Station, Experiment, Georgia.

34. The nutritive value of oats harvested in the boot, milk, and hard dough stages of maturity. O. H. HORTON, University of Arkansas.

35. Saccharin supplementation in the diet of ruminants. L. L. RUSOFF, W. J. A. PAYNE, E. J. STONE, AND G. A. HINDERY, Louisiana State University.

36. Some results of measuring cellulose digestion of forages by small sample techniques. J. W. LUSK AND J. T. MILES, Mississippi Agricultural Experiment Station.

37. The proximate analysis of lignin isolated from various dry roughages. O. T. STALLCUP, University of Arkansas.

38. The utilization of wood pulp as a roughage replacer in experimental dairy rations. G. F. WILLIAMS, S. D. MUSGRAVE, J. D. SCHUH, AND R. W. MACVICAR, Oklahoma State University.

Recent Deaths

G. E. HAWLEY, Grand Rapids, Mich., a member of the A.D.S.A. for the past four years, died March 16, 1957, in an airplane crash.

HERBERT E. OTTING, 68, retired chief chemist for the M. & R. Dietetic Laboratories, Inc., died Nov. 17, 1957, at his home in Minerva Park, O.

Dr. Otting had been head of quality control at M. & R. Dietetic Laboratories from 1929 until his retirement in 1954. At the time of his death he was active as a member of the board of directors of the company and had been serving in an advisory capacity to the firm.

A graduate of Ohio State Univ., Columbus, he served as a chemist with the John Wilde Evaporated Milk Co., Columbus, Nestle's Food Company, New York City, The Carnation Company, Corry, Pa., and Moores and Ross Milk Company, Columbus, O.

He was author of a number of technical articles in his field and was granted 14 patents in the field of milk and food processing during the years he was associated with M. & R.

A long-time member of the A.D.S.A., Mr. Otting was honored as a life member of the Association at its 50th Annviersary meeting in 1956 at Storrs, Conn.

At the time of his retirement he was also a member of the American Chemical Society, the American Oil Chemists' Society, and the Institute of Food Technologists.

DELMAR J. YOUNG, extension professor in dairying, Univ. of Delaware, Durham, died suddenly Nov. 28, 1957, in New York City.

He had been the extension professor of dairying at Delaware since 1945. Before that he was in extension work in New York and Virginia.

A graduate of Ohio State Univ., Columbus, he received his M.S. degree from Michigan State Univ., East Lansing.

Clemson News

The Clemson College Market Milk Clinic and Conference will be held Feb. 11-12 in the college's Food Industries Building, Clemson, S. C.

Chairman of the event is D. M. GRAHAM of Clemson; clinic judge will be R. F. WARREN, North Carolina State College, Raleigh; and R. C. EDWARDS, Clemson, will be the banquet speaker.

Prof. Warren will speak on flavor problems. Other speakers will be H. A. JOHNSON, Pet Dairy Products Co., Greenville, S. C., and C. B. REEVES, Clemson College Extension Service. A panel discussion will be held on the subject of vacuum pasteurization of milk.

The South Carolina Dairy Association held its annual meeting in November at the Frances Marion Hotel, Charleston.

Featured speakers at the event were H. DE GRAFF, Babcock Professor of Food Economics, Cornell Univ., Ithaca, N. Y.; KENNETH MCFARLAND, educator, speaker and consultant for General Motors Corporation and

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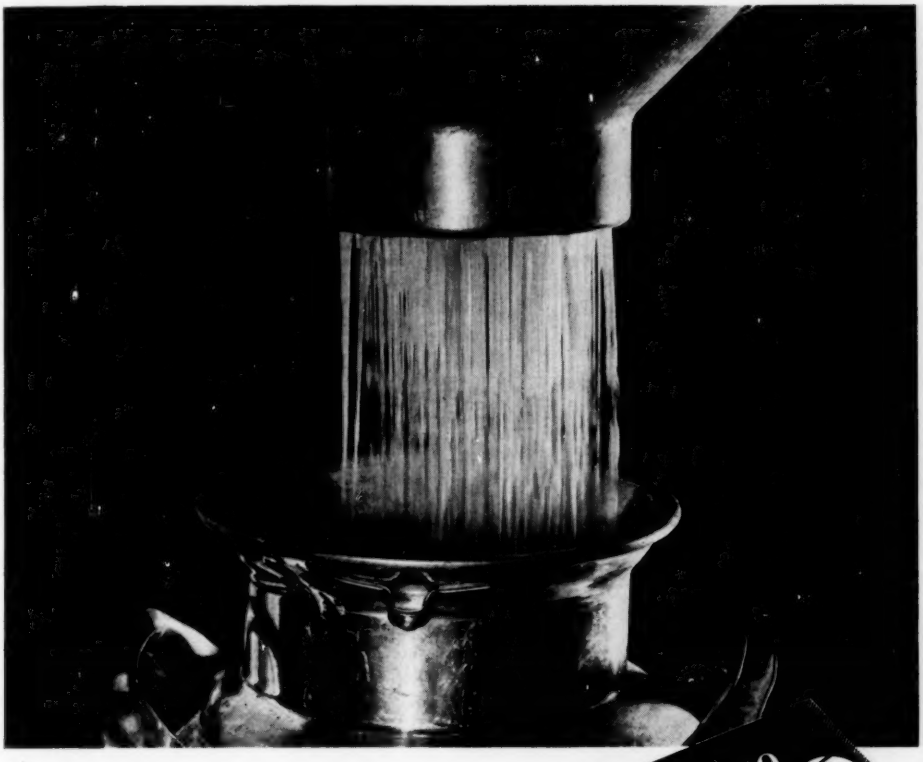

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the American Trucking Associations, Topeka, Kan.; and J. P. LaMaster, Clemson.

The Association established three new $1,000 scholarships for junior dairy students.

Oklahoma Holds Cheese Festival

The Seventh Annual Cheese Festival was held in October on the Oklahoma State Univ. campus, Stillwater. More than 2,000 people attended.

Featured attractions were displays of Christmas gift cheese packages, displays on the nutritional value of cheese, and demonstrations on the use of cheese in meal planning.

The purpose of the show was to acquaint people with various types of cheese available to them and to encourage the use of cheese. The festival is held each year on the Oklahoma campus.

Ohio State News

C. V. Morr has joined the staff of the Dept. of Dairy Technology, Ohio State Univ., Columbus. He will conduct research on antibiotics under a U. S. Public Health Service grant.

Morr received his B.S. and M.S. degrees from Ohio State and is currently doing further graduate study there.

The Dept. of Dairy Technology entertained some 45 freshman students in agriculture recently. Purpose of the meeting was to tell the students about work in dairy technology and about the job opportunities awaiting graduates in the field.

Borden's News

The Borden Company has announced the election of a new executive vice president, four new vice presidents, and the formation of a new Western Division.

Officers elected were:

R. D. Wooster, a Borden executive for 34 years, was elected executive vice president; F. R. Elliott was elected vice president to succeed Wooster in charge of fluid milk and ice cream operations; R. J. Kunz, former president of the special products division, was elected vice president; E. L. Noetzel, former treasurer of the company, became a vice president, and L. W. Bayles, former president of Drake Bakeries, a subsidiary of Borden's, was the fourth new vice president.

The new division, to be known as the Borden Company, Western Division, will have its headquarters in San Francisco and will comprise all of the company's dairy and food products operations in an 11-state area.

The Western Division will have G. F. Morrill as president; A. S. Parlett, executive vice president; D. N. Carlsen, D. J. Louis, and L. S. Merrill, vice presidents; P. L.

SCOTT, treasurer and secretary, and R. B. KEATOR, chairman of the division's directing board.

Ground has been broken for a 60,000-square foot modern ice cream manufacturing plant for the Borden Company, Syracuse, N. Y. Site of the new plant is Industrial Park.

With a capacity of two million gallons a year, the new plant will employ about 100 persons from the Syracuse area. Its design includes a specially engineered hardening tunnel; 6,200 square feet of freezer space; 2,500 feet of air-conditioned offices, and the most modern machinery for manufacturing ice cream and all types of ice cream novelties.

The plant's distribution area will include central and northern New York State.

HAROLD R. FAGERSON, who started driving a Borden milk wagon in Chicago 33 years ago, has been named president and general manager of the Chicago Milk Division of the company. He was previously vice-president in charge of sales of the division, and his most recent position was vice-president of the Chicago-Central fluid milk and ice cream district of the Borden Company.

Mr. Fagerson succeeds W. N. WATERSTREET, who has been named procurement manager of the Chicago-Central district.

Additional production of cottage cheese for the New York City market will be launched early next year in a new Watertown, N. Y., plant being constructed by the Hygienic-Northern District of Borden's Farm Products of New York.

The cottage cheese production facilities will be housed in an L-shaped addition to the company's cream-separation plant, the former Hygienic Dairy Company, in Watertown. This plant, and feeder plants in Adams and Cape Vincent, N. Y., were acquired last March by the Borden Company.

The construction, which is scheduled for completion on Jan. 1, also includes a building 150 by 50 feet, to house additional plant tanks.

P. K. HOLLENBACH, manager of the Borden Company's ice cream plant at Louisville, Ky., will retire in June, 1958. S. B. WOOD, Kokomo, Ind., will be his successor.

Mr. Hollenbach has been in the ice cream business in Louisville for 36 years. He was one of the founders of the Butterman Ice Cream Company, acquired by Borden's in 1950.

Mr. Wood is a native of Kentucky and has been employed by the Borden Company since 1921. He managed the Company's Kokomo ice cream plant for 29 years and assumed his new duties in Louisville on Nov. 1. The new manager of the Kokomo ice cream plant will be

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P. W. DAVIS of Indianapolis. He has been in the sales department of Borden's ice cream plant in Indianapolis for the past five years.

Cornell News

Two Cornell Univ. Dairy Dept. staff members have returned to campus from trips to Europe where they visited scientific laboratories and manufacturing plants.

B. L. HERRINGTON spent some seven months in Europe, particularly in Denmark where he was a Fulbright Lecturer at the Royal College of Veterinary Medicine and Agriculture. From there, Dr. Herrington visited dairy research laboratories in most of the Scandinavian countries, Germany, Austria, Switzerland, Italy, France, Belgium, The Netherlands, England, and Scotland.

W. K. JORDAN returned from an eight-month sabbatical leave spent principally in Sweden at the Wedholms AB Company, a dairy and food plant equipment manufacturer. Dr. Jordan was working on heat transfer problems in plate heat exchangers, design of farm bulk milk tanks, and instrumentation for HTST pasteurizers. He also traveled widely throughout the Scandinavian countries, Western Europe, and England.

Samuel Brody Lectureship Established

Announcement has been made of the establishment of the SAMUEL BRODY Memorial Lectureships at the Univ. of Missouri, Columbia. In establishing this memorial, the committee stated:

> Dr. Brody's stature as an individual and as a scientist has provided us with a standard by which all of us can measure our achievements. He brought honor to his institution and scientific and human understanding to his students and colleagues. We feel that his brilliant and significant work should be commemorated by a memorial in order that his influence can, to some degree, remain with us.
>
> We believe that the most appropriate memorial would be to establish a permanent lectureship to be delivered on the Univ. of Missouri campus by a distinguished worker in agricultural science. The frequency of the lectures will depend on the funds the committee is able to raise. We hope, if funds permit, to make the lecture available each time in printed form.

Any donations to this project will be greatly appreciated by the committee and may be sent directly to H. D. JOHNSON, Chairman, Samuel Brody Memorial Committee, Eckles Hall, Univ. of Missouri, Columbia.

Annual Wisconsin Dairy Meeting To Be Feb. 5-7

The Annual Wisconsin Dairy Manufacturers' Conference will be held Feb. 5-7, 1958, on the Univ. of Wisconsin campus, Madison. More than 50 speakers from universities, the government, and industry will participate in the program.

The two-day event combines the Annual Wisconsin Dairy Manufacturers' Conference, a Joint Meeting of the Dairy Manufacturers and Wisconsin Dairy Plant Fieldmen's Conference, and the Dairy Plant Fieldmen's Conference.

The following two symposia will be held on the first day of the meeting:

The Future in Packaging Dairy Products—K. ROYER, Purity Cheese Co., Mayville, Wis., *chairman;* H. I. WATSON, Aluminum Company of America, Milwaukee, Wisc.; R. W. ROBERTS, The Cryovac Company, Cedar Rapids, Ia.; S. O'CONNELL, Thatcher Manufacturing Company, Elmira, N. Y.; W. F. SNYDER, Marathon Division, American Can Company, Neenah, Wis.; D. DAVIS, Milprint, Inc., Milwaukee, Wis.; and T. E. DOBBINS, American Can Company, Maywood, Ill.

The Future in Dairy Products—H. C. JACKSON, *chairman,* W. V. PRICE, H. E. CALBERT, A. M. SWANSON, W. C. WINDER, AND K. G. WECKEL, all of the Univ. of Wisconsin, Madison.

The following section meetings will also be held: The Future in Dry Milk, The Future in Market Milk, The Future in Ice Cream, The Future in Cottage Cheese, and The Future in Quality and Procurement.

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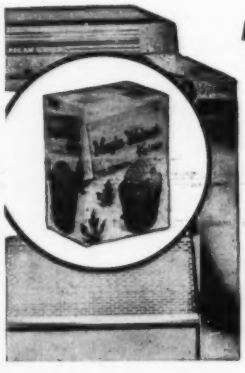

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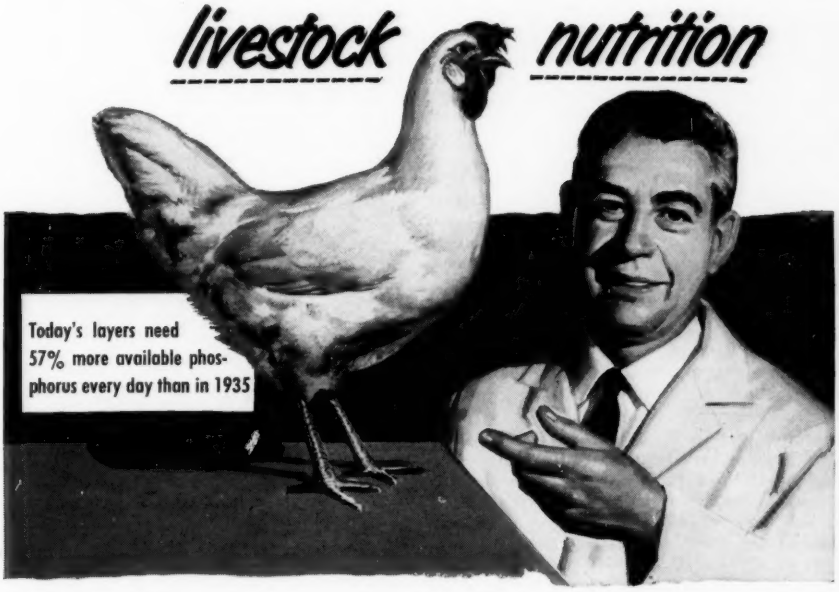

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The Dairy Fieldmen's Conference will be conducted by P. WELSH, Pet Milk Co., New Glarus, Wis. Other participants will be M. P. DEAN, J. CROWLEY, AND N. N. ALLEN, all of the Univ. of Wisconsin; O. J. MUEGGE, Wisconsin State Board of Health; W. GROVES, Wisconsin Dairy Federation, and C. NEITZKE AND R. DICKE, both of the Univ. of Wisconsin.

Annual Dairy Products Improvement Meeting to Be Held Feb. 13

The Eleventh Annual Meeting of the Dairy Products Improvement Institute, Inc., will be held Feb. 13, 1958, in the Hotel Governor Clinton, New York City.

Institute President, A. C. FISHER, General Ice Cream Corporation, Scheneetady, N. Y., has announced that the program this year will feature discussions of trade barriers, quality control developments, a new farm inspection form for industry, and milk dating.

The meeting will begin at noon with a luncheon, after which W. O. SKINNER, chief of the Milk and Ice Cream Section, Westchester County, New York Department of Health and president of the New York State Association of Milk Sanitarians, will report on "The New Industry Farm Sanitation Report Form." Then EVERT WALLENFELDT, Univ. of Wisconsin, Madison, will discuss "Quality Standard Developments and Achievements in Milk for Manufacturing in the Midwest." Following this address L. F. HERRMANN, head of the Dairy Division, Agricultural Marketing Service, USDA, Washington, D. C., will discuss "Trade Barriers in the Dairy Industry."

HARRY POLIKOFF, New York City attorney, who has been active in milk marketing hearings and cases involving sanitary regulations, will review court decisions affecting trade barriers and sanitation regulations in the dairy industry. The final speaker on the program will be A. C. DAHLBERG, Cornell Univ., Ithaca, N. Y., who will discuss the recent study of the dating of pasteurized milk in New York City which he directed.

N. Carolina Short Course To Be Feb. 17-28

A Market Milk and Ice Cream Short Course will be held Feb. 17-28 at North Carolina State College, Raleigh.

The course is designed for those who want the fundamentals of milk and ice cream processing. Most of the time will be spent on the essentials of composition, pasteurization, homogenization, cooling, cleaning and sanitization of equipment, separating and standardizing, control of undesirable bacteria, culture making, maintenance of equipment, freezing and storage of ice cream, and some arithmetical calculations pertaining to the processing of fluid milk products and frozen desserts.

The material presented will cover those aspects that are so difficult to teach to a man while he is working on his job.

Kentucky News

The Fifth Annual Dairy Manufacturing Short Course was held recently at the Univ. of Kentucky, Lexington. The short course is sponsored by the Dairy Section of the University and the Dairy Products Association of Kentucky.

Participants in the program were P. R. ELLSWORTH, Milk Industry Foundation, Washington, D. C.; W. V. PRICE, Univ. of Wisconsin, Madison; F. E. GUNN, Hart County Creamery, Horse Cave, Ky.; W. A. KRIENKE, Univ. of Florida, Gainesville; E. W. GAUMNITZ, National Cheese Institute, Chicago; L. E. MAYHUGH, Plainview Farms Dairy, St. Matthews, Ky.; W. E. GLENN, Univ. of Kentucky; B. J. DEMOTT, Univ. of Tennessee; A. W. RUDNICK, JR., Univ. of Kentucky; B. R. WEINSTEIN, Crest Foods Company, Ashton, Ill.; W. WEED, Foote and Jenks, Inc., Jackson, Mich.; and H. E. BIHELMER, Cherry Burrell Corporation, Cedar Rapids, Ia.

A new feature of the short course was a milk-scoring contest. First place winner was R.

CONNOR, Falls City Cooperative, Louisville, Ky. Second and third place winners were M. L. BEERE, Walnut Grove Dairy, Louisville, Ky., and J. W. DURBIN, Kentucky State Dept. of Health, Louisville.

Guest speaker for the short course banquet was J. G. HAYS, Professor Emeritus, Michigan State Univ., East Lansing.

J. O. BARKMAN, Univ. of Kentucky Dairy Section, was honored recently for his 38 years of service to the dairy industry of the state. The occasion was a testimonial breakfast and dedication sponsored by the Central Kentucky Manufactured Milk Improvement Association, the Kentucky Cream Improvement Association, the Dairy Products Association of Kentucky, the Univ. of Kentucky Dairy Science Club, and the Dairy Section of the Univ. of Kentucky.

During the celebration Prof. Barkman was given a new automobile. Funds for the car were contributed by more than 500 of his friends and colleagues.

Another highlight of the morning program was the dedication of the Barkman Dairy Products Laboratory, a remodeled version of the University Dairy Products Plant. University and state dignitaries at the event were D. M. SEATH, head of the Dairy Section; F. J. WELCH, dean of the College of Agriculture and Home Economics; F. G. DICKEY, president of the Univ. of Kentucky; and B. BUTLER, Kentucky State Commissioner of Agriculture.

A plaque near the entrance of the laboratory is inscribed as follows: "Barkman Dairy Products Laboratory, named in honor of Professor John Orville Barkman for his 38 years of distinguished service to the University of Kentucky and to the dairy industry of Kentucky."

Prof. Barkman, now in his seventy-first year, is still active with the University as a consultant to industry groups and supervisor of scholarships in dairy manufacturing.

In his 38 years of service, he has served both as an extension professor and as a teacher in the dairy laboratories. He was instrumental in the founding of the Central Kentucky Manufactured Milk Improvement Association and the Kentucky Cream Improvement Association. He also has been an advisory member of the board of directors of the Dairy Products Association of Kentucky.

Von Krosigk Joins Oregon Staff

C. M. VON KROSIGK recently joined the Dairy Dept. staff at Oregon State College, Corvallis. A graduate of Oregon, he received his M.S. degree in animal breeding from Iowa State College, Ames. He plans to complete work for the Ph.D. at Iowa concurrently with his work at Oregon.

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Texas Tech Holds Short Course

The Ninth Annual Dairy Industry Short Course was held in November at Texas Technological College, Lubbock. Featured speakers were I. A. GOULD, Ohio State Univ., Columbus, and R. PAXTON, Sutherland Paper Company.

M.S.U. Names R. G. Hansen as Ag. Chem. Head

R. G. HANSEN, head of the Biochemistry Division, Dept. of Dairy Science, Univ. of Illinois, Urbana, has resigned his position to accept a position as head of the Dept. of Agricultural Chemistry at Michigan State Univ., East Lansing.

Dr. Hansen received his Ph.D. degree from the Univ. of Wisconsin, Madison, in 1948, and prior to his work at Illinois was on the staff at the Univ. of Utah, Logan.

Keener Promoted at New Hampshire

H. A. KEENER, professor of Dairy Husbandry, Univ. of New Hampshire, Durham, has been appointed Director of the New Hampshire Agricultural Experiment Station effective Jan. 1, 1958.

The new appointment was made in view of recent reorganization of the College of Agriculture. Under the new system, all agricultural activities at the University have been coordinated under the College of Agriculture with H. C. GRINNELL continuing as dean of the college; but the Experiment Station has been set up as a separate unit.

Dr. Keener will continue his activities in the Dept. of Dairy Husbandry on a part-time basis. He will supervise the research work in dairy cattle nutrition, continue to administer the graduate program in cattle nutrition, and serve on the department's instructional staff.

Completed Theses

M. S. Degree

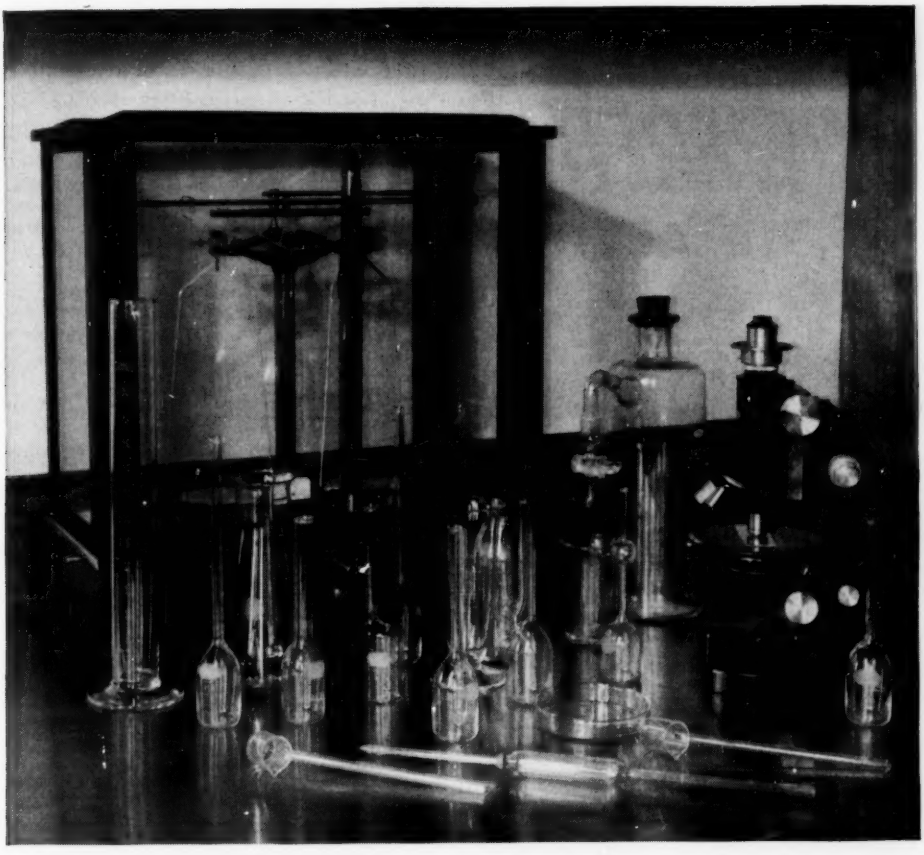
W. GIFFORD CROTHERS—Lima bean vine silage for dairy heifers. Univ. of Delaware, Durham.

GEIR VALBERG GUDNASON—The preparation and acceptance of fruit flavor milks. Cornell Univ., Ithaca, N. Y.

ROBERT J. RIFKIN—Development of alloxan diabetes in the immature bovine with respect to the protective role of endogenous glutathione and its subsequent destruction. Univ. of Delaware, Durham.

Penn State News

R. S. ADAMS, Pennsylvania State Univ., University Park, has been appointed cattle and



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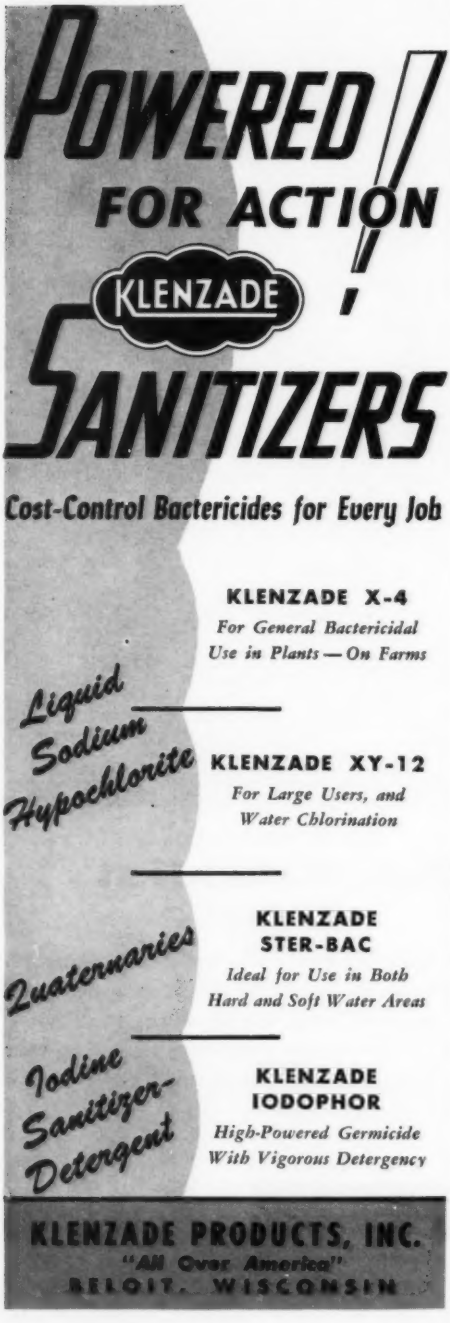

sheep research specialist at General Mills Larro Research Farm here.

Dr. Adams, a native of Auburn, Me., earned his B.S. degree in animal husbandry from the Univ. of Maine, Orono, in 1950, and his Ph.D. degree in dairy husbandry from the Univ. of Minnesota, St. Paul, in 1955.

For the past three years he has been assistant professor of dairy extension at Pennsylvania, where he developed a system of dairy demonstration farms throughout the state, and was responsible for dairy feed formulation at the state prison feed mill.

In his new position Dr. Adams will plan and carry out feeding and management research for dairy and beef cattle and sheep on the General Mills farm.

Swiss Scientist Visits M.S.U.

H. N. NITSCHMANN, internationally known protein chemist from Bern Univ., Switzerland, recently visited the Dept. of Dairy, Michigan State Univ., East Lansing. During his visit to the campus, he presented a seminar paper on his studies relating to the rennet clotting of milk.

STUDENT CHAPTER NEWS

A section devoted to the activities of dairy students

J. E. JOHNSTON, *Editor*

Minnesota Dairy Science Club News

The first meeting of the school year was in the form of a faculty-student mixer. Dr. C. L. Cole, Head of the Dairy Department, introduced all faculty members, and a tour of the department was conducted to acquaint new students with research and educational facilities. Professor W. B. Combs reported on the new dairy industry building now under construction, and announced that the first unit would be ready for occupancy before the end of the current school year. Work on the second unit will begin within the near future.

Mr. Roy Burkholder, Supervisor of Minnesota State Institution farms, was the principal speaker at the December meeting. He gave an excellent report on dairy production and milk processing facilities at the various institutions.

Club members are again planning to serve a dairy lunch to visitors attending annual Farm and Home Week activities in January. Profits will be used to promote club projects.

Plans are under way to again publish a quarterly newsletter to supply the need for better communications among students and between students and the dairy department staff.

Texas Tech News

On November 9, 1957 the Dairy Industry Club of Texas Technological College held its Twenty-second Annual Homecoming Breakfast. As has been the tradition in the past, Club members met, prepared and served breakfast for the guests. The breakfast highlights the homecoming activities for returning alumni each year. A total of sixty-seven alumni, guests, and members were present.

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COMPARATIVE INFLUENCE OF HARD AND SOFT WATER ON MILK PRODUCTION OF DAIRY COWS[1]

T. H. BLOSSER AND B. K. SONI
Department of Dairy Science, State College of Washington, Pullman

Confirmatory evidence revealed that there were no differences in the performance and feed consumption of 27 lactating cows consuming either hard or soft water. *Editor.*

Several reports have appeared in farm magazines claiming that water softened by an ion-exchange process was superior to hard water for lactating dairy cows. Until recently, no controlled experiments had been reported on this subject.

Graf and Holdaway *(1)*, using six pairs of cows in a reversal type of experiment, observed no differences in performance of cows when hard and soft water were the experimental variables.

The purpose of the experiment reported herein was to determine the value of softened and aerated water, as compared with that of hard water, for lactating dairy cows.

EXPERIMENTAL PROCEDURE

Initially, 28 cows (16 Holsteins, 8 Jerseys, and 4 Guernseys) were started on the trial. These cows were divided into two comparable groups, based on level of production, body weight, and stage of lactation and gestation. (One Holstein was removed from the trial because of a foreign body in the reticulum; therefore, data are available for only 27 cows.)

This trial was run concurrently with one on dehydrated forage, in which four treatments were involved. A Latin-square design was used in the dehydrated-forage experiment. The experiment was divided into four, 6-wk. periods with a 1-wk. transition between each two experimental periods. During any given 6-wk. period, one-half of the cows were receiving soft water and one-half hard water. At the end of 6 wk., the water treatments were reversed, as they were at the end of the second and third 6-wk. periods. Thus, the soft-water trial was a double-reversal type trial. Each cow on experiment was on hard water for a total of 12 experimental weeks.

Details of the design are indicated (Table 1).

Feeding. Individual feeding was practiced throughout the trial. All feeds were weighed. Average-quality chopped alfalfa hay was supplied ad libitum. Grass silage was fed during the first month of the experiment and pea-vine silage during the last 5 mo., at the rate of 3 lb. per 100 lb. of body weight daily. Grain was fed for a given week at the rate of 1 lb. per 3 lb. of 4% fat-corrected milk (FCM) produced during the preceding week. The grain contained in poundages: ground barley, 230, ground cull peas, 200, ground corn, 100, ground oats,

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TABLE 1
Design of experiment

Group	Experimental period I	II	III	IV
		(Treatments)[a]		
1	A (H-S)	B (S-H)	C (H-S)	D (S-H)
2	D (H-S)	A (S-H)	B (H-S)	C (S-H)
3	C (H-S)	D (S-H)	A (H-S)	B (S-H)
4	B (H-S)	C (S-H)	D (H-S)	A (S-H)

[a] A—Control grain ration; B—30% grain replacement with regular dehydrated, pelleted cereal grass; C—30% grain replacement with regular dehydrated, pelleted alfalfa; D—30% grain replacement with regular dehydrated, chopped cereal grass; H—hard water, S—soft water.

300, linseed meal, 50, wheat mixed feed, 100, steamed bone meal, 10, and iodized salt, 10.

Data collected. The cows were weighed on two consecutive days at the end of each experimental week, and on three consecutive days at the beginning and end of each experimental period. Each milking was weighed and milk samples were composited and tested for percentage butterfat at the end of each experimental week. Feed weigh-backs were made routinely and were chemically analyzed. Results of chemical analyses of the feeds are presented (Table 2).

The TDN content of the feeds was calculated by using appropriate digestion coefficients as listed in Morrison *(2)*, for all except the dehydrated forages. For these materials, TDN was determined in digestion trials with sheep, following methods described by Murdock *et al. (3)*.

Chemical analyses and standard error of the weigh-backs are given (Table 3). There were no grain or dehydrated-alfalfa weigh-backs. The composition of the small amount of silage weigh-backs was much like that of the silage fed, except for dry matter. Appropriate corrections were made for dry matter in calculating the TDN consumed by the cow. The statistical analyses of the data were made essentially as outlined in Snedecor *(4)*.

TABLE 2
Chemical analyses of the feeds used on an as-fed basis

Feed	Samples analyzed	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract
	(No.)			*(%)*			
Alfalfa hay	8	91.39	10.95	1.59	34.79	7.04	37.03
Grass-legume silage	4	26.00	3.40	1.02	7.77	2.83	10.98
Pea-vine silage	7	30.19	3.31	1.15	8.89	2.95	14.09
Grain mix	8	90.49	14.79	3.72	7.34	4.66	59.98
Grass, dehydrated, pelleted	9	90.54	19.28	5.70	20.77	6.89	37.89
Grass, dehydrated, chopped	9	91.91	20.62	6.40	23.07	7.61	34.21
Alfalfa, dehydrated, pelleted	9	90.76	15.36	3.80	22.74	10.19	38.67

TABLE 3

Chemical analyses and standard errors of hay weigh-backs for treatments, as-fed basis

Treatment	Analyses	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	NFE
	(No.)			*(%)*			
Hard water	54	91.91 ± 0.26	8.37 ± 0.18	1.17 ± 0.03	42.75 ± 0.38	5.61 ± 0.08	33.94 ± 0.31
Soft water	54	92.31 ± 0.14	8.44 ± 0.14	1.17 ± 0.03	42.77 ± 0.33	5.75 ± 0.07	34.18 ± 0.18

The water consumed in the experiment was measured by means of an individual meter above the drinking cup of each cow. Daily meter readings were taken. The water was softened for one-half the cows on experiment by means of the usual ion-exchange zeolite process.

RESULTS AND DISCUSSION

The lactation decline for 4% FCM of cows on hard and soft water, when the data are condensed into a 6-wk. experimental period, are shown (Figure 1). It is evident from this that there was little difference between treatments either in level of production or in rate of lactation decline. Statistical analyses also show no significant difference between treatments. Table 4 shows feeds used, fat, milk and FCM produced, total water consumed per cow daily, and water consumed per lb. of 4% FCM produced. The average daily butterfat production per cow on hard water for the entire experiment was 1.12 lb., as compared with 1.08 lb. per cow on soft water.

Since, in the process of softening, the composition of water is changed, one might expect to find some differences between water consumption of cows on hard and on soft water. However, data presented (Table 4) show that cows on hard water did not differ greatly from cows on soft water, in amounts of water drunk. Average pounds of water consumed per cow daily for the entire experiment were: hard water, 102.1; soft water, 101.5.

TABLE 4

Feeds consumed, milk and fat-corrected milk produced, fat produced, and water consumed per pound of fat-corrected milk, produced per cow daily by treatments

	Treatment	
	Hard water	Soft water
	(lb/cow/day)	*(lb/cow/day)*
Feeds consumed		
Hay	13.7	13.0
Silage	34.7	34.9
Grain	7.0	7.5
Dehydrated forage	2.6	2.8
Milk produced	27.4	27.1
FCM produced	27.7	27.0
Butterfat produced	1.12	1.08
Free water consumed	102.1	101.5
Free water consumed/lb 4% FCM produced	3.73	3.90
Average body weight gain	0.30	0.32

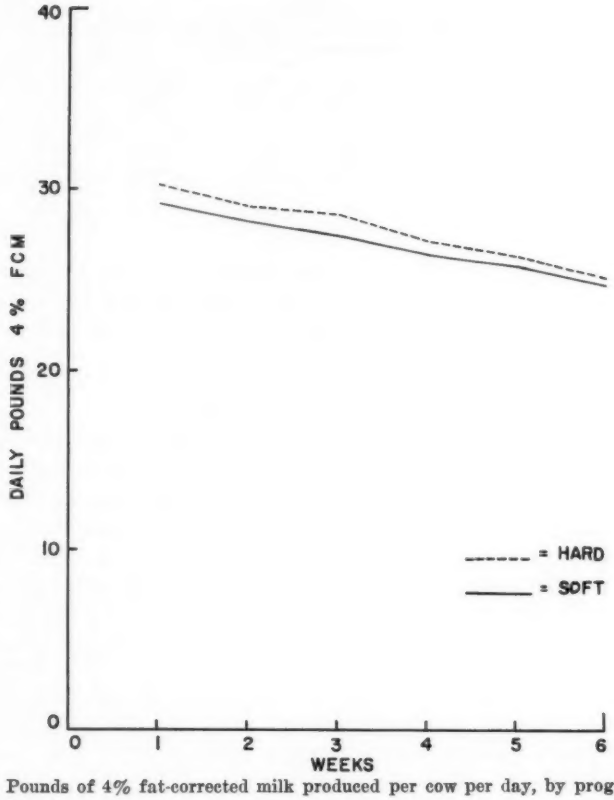

FIG. 1. Pounds of 4% fat-corrected milk produced per cow per day, by progressive weeks of the experiments.

Another way of expressing water consumption is on a per lb. of 4% FCM basis. As might be expected, since there were no striking differences in water consumption or in 4% FCM produced between the hard- and soft-water treatment, there was no significant difference between treatments in pounds of water consumed per lb. of 4% FCM produced.

The compositions of hard and of soft water used are shown (Table 5). Both major and minor constituents are presented. Four samples each of hard and soft water were analyzed over the 4-mo. period of the experiment. The analyses show that the hardness was reduced from 6.8 to 0.49 gr. of $CaCO_3$ per gallon. The only major constituents in hard water showing appreciable variation were sulfate, chloride, and potassium. The total dissolved solids in the soft water were 25% higher than in the hard water. The concentration of carbonate, bicarbonate, chloride, sulfate, and citrate were not appreciably different in the two sets of samples. The silicon dioxide was reduced 32% in the softening process. The sodium content, as would be expected, was slightly over three times as high

TABLE 5

Average compositions of hard and soft water consumed by cows on experiment

	Hard water	*Soft water*
	——(p.p.m.)[a]——	
pH	8.0	8.0
Dissolved solids (105° C.)	206.0	246.2
Dissolved solids (600° C.)	166.7	209.4
Carbonate (CO_3)	4.4	4.6
Bicarbonate (HCO_3)	187.7	194.8
Chloride (Cl)	8.3	7.9
Sulfate (SO_4)	5.7	3.6
Nitrate (NO_3)	.8	1.0
Silicate (Si_2O_3)	63.5	43.8
Sodium	24.3	79.9
Potassium	7.6	6.0
Aluminum	1.04	.93
Barium	0.80	.001[c]
Boron	.58	.04
Calcium	12.4	.48
Chromium	.003[b]	.....
Cobalt	.....	.....
Copper	.04	.03
Iron	.05	.08
Lead	.....	.....
Magnesium	20.6	.69
Manganese	.05	.05[c]
Molybdenum	.....	.....
Nickel	.....	.004[c]
Phosphorus	.....	.....
Silver	.001[b]	.....
Strontium	.50	.005[b]
Tin	.008	.01[b]
Titanium	.004	.....
Vanadium	.003[c]	.....
Zinc	.....	.....
Hardness expressed as grains $CaCO_3$ 1 gal. water	6.8	.49

[a] Unless otherwise indicated, these figures represent average of four hard- and four soft-water samples.

[b] One sample was used in determining the average of the substance indicated. Other samples devoid of this element.

[c] Two sampes were used in computing the average of the substance indicated. Other samples devoid of this element.

in the soft as in the hard water. The total hardness was reduced more than 90%.

Spectrographic analysis of the dissolved solids shows that strontium and barium are almost quantitatively removed from the water by the softening process. The trace elements found in measurable quantities were: aluminum, barium, copper, iron, manganese, strontium, tin, titanium, and vanadium.

It is clear, as a result of the experiment, that there is no difference between hard and soft water in their effects on milk or fat production of dairy cows. Neither is there any difference in amounts of the two types of water consumed by cows. Those results confirm those of the experiment conducted by Graf and Holdaway *(1)*.

It should be emphasized that the results of the experiment reported herein apply only to the conditions of water hardness prevailing in Pullman, Washington. The results do not preclude the possibility that under conditions of greater water hardness some beneficial effect might occur. Furthermore, it should be

pointed out that this trial lasted for only one-half of one lactation. A more extended experiment might possibly have given different results.

It seems unlikely, however, under condition of average water hardness, that beneficial effects will result from the softening process. Taking into consideration the chemical changes in the water during softening, there does not appear to be any known physiological basis for expecting superior performance from softened water.

SUMMARY

A 28-wk. trial, involving 27 cows in a double-reversal trial, was run to determine the influence of softened water (as compared with hard water) on the performance of lactating dairy cows. This study demonstrated that there was, (1) no significant difference between hard- and soft-water treatments in 4% FCM or in butterfat produced; (2) little difference in water consumed, and (3) essentially no difference in the water consumed per pound of 4% FCM produced.

ACKNOWLEDGMENTS

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REFERENCES

(1) Graf, G. C., and Holdaway, C. W. A Comparison of Hard and Commercially Softened Water in the Ration of Lactating Dairy Cows. *J. Dairy Sci.*, **35**: 998. 1952.

(2) Morrison, F. B. *Feeds and Feeding.* 21st ed. Morrison Publ. Co., Ithaca, N. Y. 1951.

(3) Murdock, F. R., Miller, V. L., Blosser, T. H., and Erb, R. E. The Composition and Nutritive Value of Alfalfa Hay Prepared by Three Methods of Curing and in Three Physical States. pp. 28-35. Proc. 32nd Meeting West. Div., Am. Dairy Science Association. 1951.

(4) Snedecor, G. W. *Statistical Methods.* Iowa State College Press, Ames. 1950.

EFFECTS OF TRACE MINERALS, AUREOMYCIN, AND OTHER SUPPLEMENTS ON CERTAIN HEMATOLOGIC VALUES AND ORGAN WEIGHTS OF DAIRY CALVES[1]

M. J. SWENSON, G. K. L. UNDERBJERG, E. E. BARTLEY, AND W. G. JONES

Department of Physiology, School of Veterinary Medicine, and Department of Dairy Husbandry, Kansas State College, Manhattan

The purpose of this work was to determine if certain blood criteria of calves or various rations could be associated with growth. Twenty-seven newborn calves were placed in three groups. Group I was fed the basal ration; Group II, basal plus trace minerals iron, copper, cobalt, zinc, manganese, and iodine, and Group III, basal plus trace minerals, major minerals, vitamins, and chlortetracycline. Trace minerals in Group II and trace and major minerals, vitamins, and chlortetracycline in Group III produced hematopoietic responses in erythrocytes, hemoglobin, and hematocrit which were evident from 2 wk. until the calves were 8 wk. old. Growth was stimulated. The size of the erythrocyte, the amount and concentration of hemoglobin in the cell, and the total leukocyte count were not affected by ration. Soon after birth some calves with high leukocyte counts contracted diarrhea and then pneumonia, but effective treatment was found. *Editor.*

In a recent publication *(9)*, the effects of trace minerals, chlortetracycline,[2] and other dietary constituents on growth and feed consumption of dairy calves were reported. It was found that newborn calves fed dietary trace minerals grew at a significantly faster rate than controls during the first 7 wk., but it was not until the 8th wk. that the spread in average size between the groups was statistically significant. From 8 to 24 wk., calves supplemented with trace minerals continued to average larger than the controls but, comparatively, there was a gradually diminishing growth rate of the calves supplemented with trace minerals. A third group of calves, fed trace minerals, major minerals, water-soluble and fat-soluble vitamins, and chlortetracycline, grew for 8 wk. at a rate similar to those fed trace minerals, but from 8 to 24 wk. this third group grew significantly faster than either the trace mineral–supplemented group or the controls, and were considerably larger at 24 wk. than those in either of the two other groups. The differences in the quantity of feed consumed and efficiency of gain among the three groups were not significant.

The purpose of this experiment was to determine whether certain food components of the calves in the various groups could be associated with differences in growth response.

MATERIALS AND METHODS

Twenty-seven newborn Ayrshire and Holstein calves were assigned at random, after grouping by sex, to three rations. Three Ayrshire females, two Ayrshire

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[1] Contribution No. 156, Dept. of Veterinary Medicine, and No. 249, Dept. of Dairy Husbandry, Kansas Agricultural Experiment Station.

[2] Aureomycin is the trademark of Lederle Laboratories Division, American Cyanamid Co., Pearl River, N.Y., for the antibiotic, chlortetracycline.

males, two Holstein females, and two Holstein males were in each group. Details of the rations fed and experimental procedure were explained previously *(9)*. Calves in Group I were fed a basal ration consisting of colostrum, whole milk, calf starter, grower ration, and alfalfa hay during the 24-wk. period. This ration met the recommended allowances of the National Research Council *(4)*. Calves in Group II received the basal ration plus trace-mineral salts at the rate of 200 mg. of iron, 20 of copper, 20 of manganese, 10 of cobalt, 10 of zinc, and 0.19 of iodine, expressed in elemental form per 100 lb. of body weight. Calves in Group III were fed the same ration as Group II, plus additional calcium, phosphorus, magnesium, vitamins (A, B-complex, C, D, E, and K), and chlortetracycline.

Blood samples were obtained from the jugular veins of the heifer calves shortly after birth (prior to nursing) and at 2, 4, 6, 8, 12, 18, and 24 wk. of age. Blood was collected in test tubes containing a dried mixture of ammonium and potassium oxalate, the method recommended by Heller and Paul *(8)* to keep the erythrocyte volume constant. The hematologic determinations consisted of total erythrocyte and leukocyte counts, hemoglobin, and hematocrit. Duplicate determinations, except hematocrits, were made on each blood sample. The mean corpuscular volume (M.C.V.), mean corpuscular hemoglobin (M.C.H.), and mean corpuscular hemoglobin concentration (M.C.H.C.) were calculated by the following formulas:

$$\text{M.C.V. (cu. } \mu) = \frac{\text{Vol. packed R.B.C. ml/1,000 ml.}}{\text{R.B.C., millions/cu mm.}}$$

$$\text{M.C.H. } (\mu\,\mu\text{g.}) = \frac{\text{Hb., gm/1,000 ml.}}{\text{R.B.C., millions/cu mm.}}$$

$$\text{M.C.H.C } (\%) = \frac{\text{Hb., gm/100 ml.} \times 100}{\text{Vol. packed R.B.C. ml/100 ml.}}$$

Hemoglobin was determined by the acid hematin method of Cohen and Smith *(5)*, using a Model 14 Coleman spectrophotometer. Hematocrits were obtained by using Wintrobe hematocrit tubes. They were centrifuged for 30 min. at 3,000 r.p.m.

The 12 bull calves were slaughtered at 24 wk. of age. The heart, lungs, kidneys, spleen, adrenal glands, thyroid, liver, and testes were removed, stripped of foreign tissue, and weighed.

RESULTS AND DISCUSSION

The hematologic data of heifer calves are given (Table 1 and Figures 1 and 2). An analysis of variance of data (not shown) from Ayrshire and Holstein calves did not reveal significant differences between breeds. Byers *et al. (2)* reported differences in hemoglobin readings between Holstein and Jersey cows. Thomas *et al. (16)* found that Red Dane and Sindhi-Jersey crossbreds had higher hemoglobin values than Jersey and Holstein calves.

Rations 2 and 3 produced a hematopoietic response manifested by an increase in number of erythrocytes in hemoglobin and in hematocrit. This response became evident within 2 wk. and lasted until the calves were at least 8 wk. of age.

TABLE 1

Average hematologic values of 15 calves (three Ayrshire and two Holstein calves per group) fed the three rations

Hematologic determinations	Rations	Age (in weeks)							
		0	2	4	6	8	12	18	24
Erythrocytes, per cu. mm. 10^6	1	9.40	8.73	9.38	9.29	9.55	9.90	10.14	9.32
	2	9.49	11.37	11.93	12.01	12.15	11.03	12.00	10.55
	3	11.44	12.01	12.94	14.73	13.02	10.98	10.69	9.92
Hemoglobin, gm/100 ml.	1	15.82	12.19	11.03	11.43	11.91	12.82	12.75	12.35
	2	15.95	15.63	16.89	17.36	15.57	14.01	13.34	12.81
	3	18.56	17.24	17.83	17.21	16.12	13.33	12.98	12.74
Hematocrit, %	1	43.30	37.50	33.70	33.40	34.50	35.30	38.00	34.00
	2	44.60	47.70	46.70	44.40	43.50	39.60	37.20	35.80
	3	47.00	48.80	49.90	47.90	43.60	35.50	36.00	34.50
Leukocytes, per cu. mm.	1	13,410	10,870	11,026	11,150	11,000	12,550	9,403	11,863
	2	15,020	11,285	11,620	10,800	9,860	12,230	10,130	10,600
	3	15,284	13,260	13,020	11,660	10,910	11,630	11,962	13,560
M.C.V., cu. μ	1	45.97	40.83	36.60	36.14	36.84	33.13	38.33	36.92
	2	47.25	42.52	39.47	38.88	35.92	36.26	32.65	34.48
	3	42.19	40.95	39.05	34.41	34.95	32.61	34.12	34.99
M.C.H., $\mu\mu$g.	1	17.00	13.91	12.56	12.32	12.64	12.80	12.94	13.51
	2	16.83	14.05	14.25	14.15	12.91	12.86	11.48	12.30
	3	16.79	13.92	13.85	12.49	12.96	12.18	12.24	12.89
M.C.H.C., %	1	37.76	32.50	34.36	34.16	34.56	36.30	35.69	37.28
	2	35.75	33.09	36.13	36.40	35.94	35.68	35.85	35.77
	3	39.97	35.26	35.52	36.03	37.28	37.46	35.96	36.91

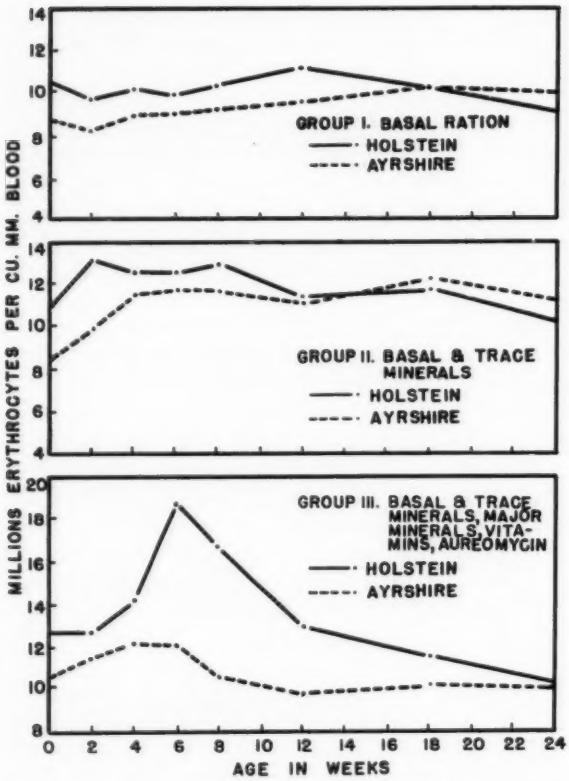

FIG. 1. Average erythrocyte counts of 15 calves (three Ayrshire and two Holstein calves per group) fed the three rations.

At 2 wk. of age, the erythrocyte counts (Table 1 and Figure 1) of calves fed Rations 2 and 3 were significantly higher (5% level) than those fed Ration 1. Similar, but not statistically significant, differences were found at 4, 6, and 8 wk. of age. After 8 wk., the erythrocyte count for Ration 2 decreased until the end of the experiment (24th wk.), at which time it was only slightly higher than at birth. After 8 wk., the erythrocyte count for Ration 3 fell below the count at birth and continued to decrease gradually until the 24th wk. Nonsignificance in counts at 4, 6, and 8 wk. was due to the greater variation in counts within treatment. For example, the range in counts for Ration 3 at 6 wk. was 11,000,000 to 25,000,000. The calf with 25,000,000 was born with 16,000,000 erythrocytes per cu. mm. of blood, which accounts for the larger average at birth for its group than for the other groups. Various investigators *(1, 6, 11, 12, 13, 14, 17)*, working with simple-stomached animals (rats, dogs, pigs, rabbits, guinea pigs, mice, chickens, and ducks), have shown that cobalt produces a polycythemia. When copper was inadequate in the ration, cobalt polycythemia was not produced in

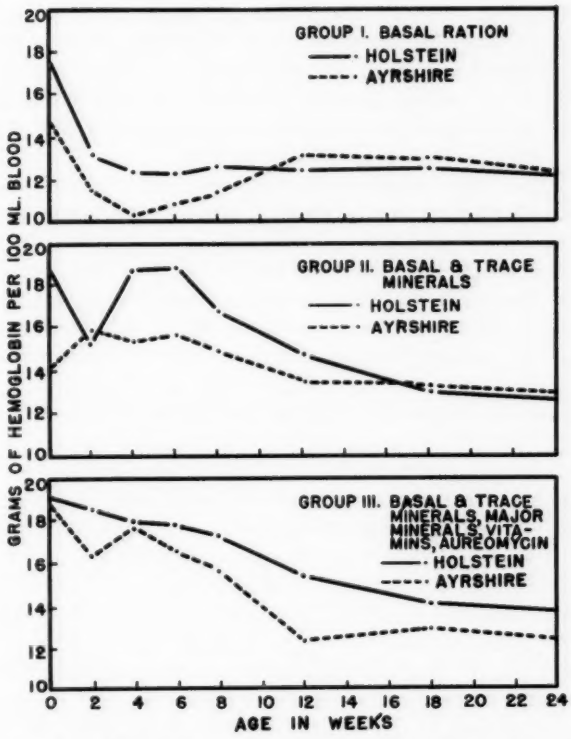

FIG. 2. Average hemoglobin values of 15 calves (three Ayrshire and two Holstein calves per group) fed the three rations.

rats. The polycythemia continued as long as cobalt was supplemented with copper and iron to whole-milk diets. In this investigation, it is unlikely that trace minerals produced a polycythemic effect, because calves fed Ration 2 did not show this effect.

The reported values for total erythrocyte counts of cattle *(3, 4, 7, 18)* vary from 4,900,000 to 9,000,000 per cu. mm. of blood; hemoglobin *(2, 3, 4, 7, 16, 18, 19)* from 7.6 to 16.5 g. per 100 ml. of blood, and hematocrits *(4, 7, 18, 19)* from 29 to 42%. The extreme variations reported for hematologic data emphasize the need for control animals in each experiment. Some of the variations can be attributed partially to conditions of the animals, because some of the reported values are from clinical cases.

At 2 wk. of age, the hemoglobin levels (Table 1 and Figure 2) of calves fed Rations 2 and 3 were similar to the levels at birth, but at this age the hemoglobin levels of the controls were lower than at birth. This difference was not statistically significant. At 4 and 6 wk. of age, the differences between the hemoglobin levels of calves fed Rations 2 and 3 and those fed Ration 1 were highly significant

(1% level); whereas, at 8 wk., these differences were significant at the 5% level. After 8 wk., the hemoglobin levels for calves fed Rations 2 and 3 approached the levels of the controls and at 24 wk. were similar to the controls. Hematocrits (Table 1) followed a similar pattern. At 4 wk., the differences in hematocrits between calves fed Rations 2 and 3 and those fed Ration 1 were highly significant, and at 2 and 6 wk. the differences were significant.

It appears that trace minerals in Ration 2 and trace minerals, major minerals, vitamins, and chlortetracycline in Ration 3, produced a hematopoietic response in dairy calves. These effects were manifested in total erythrocyte counts, and in hemoglobin and hematocrit. The response became evident within 2 wk. and lasted at least through 8 wk. This period corresponded with the time when accelerated growth responses were present in calves fed Rations 2 and 3 *(9)*. Thomas *et al. (16)* reported a significant correlation between hemoglobin levels and weight gains of calves. The accelerated growth obtained from Ration 3 during the latter third of the experimental period was not reflected in the hematologic values.

The total leukocyte counts were not affected by rations (Table 1). The higher leukocyte counts at birth were similar to subsequent values. The reported values for total leukocyte counts varied between 4,300 and 14,100 per cu. mm. of blood *(3, 4, 7, 18)*. During the course of this experiment, some of the calves were affected with diarrhea shortly after birth. The calves with diarrhea developed temperatures of from 105 to 106° F., labored breathing, and pneumonia. Calves which developed diarrhea had leukocyte counts of from 14,000 to 25,000 per cu. mm. of blood at birth. Calves with leukocyte counts of from 10,000 to 13,000 remained free of diarrhea and pneumonia at birth. Some of these, however, contracted the disease later in the experiment, but it was of a milder form. When the newborn calves became morbid shortly after birth, a high mortality resulted. To save sufficient animals for the experiment, all calves born with 14,000 or higher leukocyte counts, with or without clinical evidence of the disease, were given penicillin intramuscularly, in conjunction with antibacterial bovine serum, No. 3,[3] for the control of calf diarrhea and pneumonia. When possible, this therapy was given immediately after the high leukocyte count was found and before diarrhea had developed. With this treatment, calves remained free from, or developed only a mild form of, diarrhea (of short duration).

The M.C.V., M.C.H., and M.C.H.C. (Table 1) were not affected by rations. The reported values for adult cattle as summarized by Wintrobe *(18)* and Coffin *(4)* vary from 49.5 to 60.7 cu. μ for M.C.V., 14.4 to 20 $\mu\mu$g. for M.C.H., and 32 to 34% for M.C.H.C. The average M.C.V. observed at birth in this experiment was 45.14: thereafter, it decreased and remained below 40. The M.C.H. followed a similar pattern by starting with 16.87 and decreasing to values between 12 and 14. The M.C.H.C. remained fairly constant for 24 wk. after birth; however, the values are slightly higher than those given by Wintrobe *(18)* and Coffin *(4)*.

The hematologic values for bull calves at 14 and 24 wk. of age are given

[3] Available from veterinary supply houses.

TABLE 2

Average hematologic values of 12 bull calves (four per group) fed three rations

Hematologic determinations	Rations	Age (in weeks)	
		14	24
Erythrocytes per cu. mm. 10^6	1	9.91	10.32
	2	12.09	10.17
	3	10.02	9.40
Hemoglobin, gm/100 ml.	1	12.24	12.25
	2	13.16	11.88
	3	13.36	11.84
Hematocrit, %	1	34.30	33.60
	2	37.00	32.80
	3	35.40	33.50
Leukocytes, per cu. mm.	1	11,538	11,125
	2	10,838	9,175
	3	12,200	12,113
M.C.V., cu. μ	1	34.76	32.98
	2	31.16	32.33
	3	35.53	35.81
M.C.H., μ μg.	1	12.38	12.05
	2	11.01	11.72
	3	13.42	12.71
M.C.H.C., %	1	35.20	35.44
	2	35.20	36.31
	3	37.63	35.48

(Table 2). These values are similar to those for the heifer calves at approximately corresponding ages. Thomas *et al. (16)* reported sex differences in hematologic values between birth and 75 days of age for dairy calves. Rations did not affect the hematologic findings of bulls. The same is true for the heifer calves at like ages.

The average weights of organs from the 12 bull calves are presented (Table 3). The weights of organs from Holsteins averaged more than those from Ayrshires. The differences in heart weights were significant at the 5% level and in lungs at the 1% level. The remaining organs (Table 3) from Holsteins were larger, but not significantly so. Rations produced a significant effect on adrenal weights (5% level). The average weight of adrenal glands from calves fed Ration 1 was 9.5 g., Ration 2, 8.4, and Ration 3, 7.95. By fortifying the basal ration with

TABLE 3

Average weights of organs from 12 bull calves (two per group) fed the three rations

Organ	Ayrshire				Holstein			
	Rations							
	1	2	3	Av.	1	2	3	Av.
	(g.)							
Heart	526	610	646	594	753	691	1,003	816
Lungs[a]	963	1,124	1,182	1,090	1,837	1,331	1,785	1,651
Kidneys[a]	436	454	598	496	617	603	647	622
Spleen	220	307	243	257	237	252	374	288
Adrenals[a]	8.7	7.8	6.7	7.7	10.3	9.0	9.2	9.5
Thyroid	12.1	19.7	19.2	17.0	19.7	18.8	21.5	20.0
Liver	1,944	2,492	2,109	2,182	2,383	2,362	2,922	2,556
Testes	63.5	84.2	79.7	75.8	90.7	83.2	121.1	98.3

[a] Combined weights of paired organs.

trace minerals, major minerals, vitamins, and chlortetracycline, the average size of the adrenal glands was reduced. It is suggested that animals fed rations fortified with these nutrients and chlortetracycline are less subject to stress; therefore, they develop a smaller adrenal gland *(15)* than animals fed an unsupplemented ration, as in the control group.

SUMMARY

Twenty-seven newborn dairy calves (15 heifers and 12 bulls) were grouped by sex and then assigned at random to three ration groups. Calves in Group I were fed a basal ration; Group II, basal plus trace minerals (iron, copper, cobalt, zinc, manganese, and iodine), and Group III, basal plus trace minerals, major minerals, vitamins, and chlortetracycline. The experiment was terminated at 24 wk.

The heifers were bled at birth and at 2, 4, 6, 8, 12, 18, and 24 wk. The bull calves were bled at 14 and 24 wk.

Trace minerals in Ration 2, and trace minerals, major minerals, vitamins, and chlortetracycline in Ration 3, produced a hematopoietic response manifested by an increase in number of erythrocytes, in hemoglobin and in hematocrit. This response became evident within 2 wk. and lasted until the calves were at least 8 wk. of age. Growth also was stimulated during this period.

Mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and total leukocyte counts were not affected by the rations. Soon after birth, some of the calves were affected with diarrhea, followed by pneumonia. These calves had high leukocyte counts at birth. A method to prevent or decrease the severity of the disease, when high leukocyte counts were obtained at birth, is suggested.

Hematologic values for bull calves at 14 and 24 wk. of age were similar to heifer calves of approximately the same ages. Rations did not produce significant differences in these values.

The weights of organs (heart, lungs, kidneys, spleen, adrenals, thyroid, liver, and testes) from Holstein bulls were larger than these organs from Ayrshires, with the heart and lungs being significantly so (5 and 1% levels, respectively). The adrenal glands from calves fed Ration 3 were significantly smaller than from those fed Rations 1 and 2, indicating that fortification of rations with nutrients and chlortetracycline may help animals withstand stress.

REFERENCES

(1) Berlin, Nathaniel I. The Distribution of Cobalt in Polycythemic Rats. *J. Biol. Chem.*, **187**: 41. 1950.

(2) Byers, J. H., Jones, I. R., and Haag, J. R. Blood Hemoglobin Values of Dairy Cattle. *J. Dairy Sci.*, **35**: 661. 1952.

(3) Calhoun, M. Lois. A Cytological Study of Costal Marrow. III. Hemograms of the Horse and Cow. *Am. J. Vet. Research*, **16**: 297. 1955.

(4) Coffin, David L. *Manual of Veterinary Clinical Pathology.* 3rd ed. Comstock Publ. Co., Ithaca, N. Y. 1953.

(5) COHEN, BARNETT, AND SMITH, ARTHUR H. The Colorimetric Determination of Hemoglobin. *J. Biol. Chem.*, **39**: 489. 1919.

(6) DAVIS, JOHN EMERSON, MCCULLOUGH, A. W., AND RIGDON, R. H. Polycythemia Produced by Cobalt in the Duck. A Hematologic and Pathologic Study. *J. Lab. Clin. Med.*, **30**: 327. 1945.

(7) DUKES, H. H. *The Physiology of Domestic Animals.* 7th ed. Comstock Publ. Co., Ithaca, N. Y. 1955.

(8) HELLER, V. G., AND PAUL, HENRY. Changes in Cell Volume Produced by Varying Concentrations of Different Anticoagulants. *J. Lab. Clin. Med.*, **19**: 777. 1934.

(9) JONES, W. G., BARTLEY, E. E., SWENSON, M. J., UNDERBJERG, G. K. L., ATKESON, F. W., AND FRYER, H. C. Effects of Supplementing a Calf Ration with Trace Minerals, Aureomycin, and Other Dietary Constituents as Measured by Growth and Feed Consumption. *J. Dairy Sci.*, **39**: 188. 1956.

(10) LOOSLI, J. K., HUFFMAN, C. F., PETERSEN, W. E., AND PHILLIPS, P. H. *Recommended Nutrient Allowances for Domestic Animals. III. Recommended Nutrient Allowances for Dairy Cattle.* National Research Council, Washington, D. C. 1950.

(11) MYERS, VICTOR C., BEARD, HOWARD H., AND BARNES, BRODA O. Studies in the Nutritional Anemia of the Rat. IV. The Production of Hemoglobinemia and Polycythemia in Normal Animals by Means of Inorganic Elements. *J. Biol. Chem.*, **94**: 117. 1931.

(12) ORTEN, JAMES M., UNDERHILL, F. ALINE, MUGRAGE, EDWARD R., AND LEWIS, ROBERT C. Polycythemia in the Rat on a Milk-Iron-Copper Diet Supplemented by Cobalt. *J. Biol. Chem.*, **96**: 11. 1932.

(13) ORTEN, JAMES M., UNDERHILL, F. ALINE, MUGRAGE, EDWARD R., AND LEWIS, ROBERT C. Blood Volume Studies in Cobalt Polycythemia. *J. Biol. Chem.*, **99**: 457. 1933.

(14) SCHULTZE, M. O. Metallic Elements and Blood Formation. *Physiol. Revs.*, **20**: 37. 1940.

(15) SELYE, HANS. *The Story of the Adaptation Syndrome.* ACTA, Inc. Medical Publishers (Montreal, Canada), **51**: 54. 1952.

(16) THOMAS, J. W., OKAMOTO, M., JACOBSON, W. C., AND MOORE, L. A. A Study of Hemoglobin Levels in the Blood of Young Dairy Calves and the Alleviation of Anemia by Iron. *J. Dairy Sci.*, **37**: 805. 1954.

(17) UNDERWOOD, E. J., AND ELVEHJEM, C. A. Is Cobalt of Any Significance in the Treatment of Milk Anemia with Iron and Copper? *J. Biol. Chem.*, **124**: 419. 1938.

(18) WINTROBE, MAXWELL M. *Clinical Hematology.* 3rd ed. Lea and Febiger, Philadelphia. 1951.

(19) WISE, G. H., CALDWELL, M. J., PARRISH, D. B., FLIPSE, R. J., AND HUGHES, J. S. Changes in Cell Volume and in Concentration of Hemoglobin and of Several Inorganic Constituents of the Blood of Calves During Early Postnatal Development. *J. Dairy Sci.*, **30**: 983. 1947.

FREEZING BOVINE SEMEN. I. TECHNIQUES FOR FREEZING BOVINE SPERMATOZOA IN MILK DILUENTS[1,2]

W. T. O'DELL AND J. O. ALMQUIST

Dairy Breeding Research Center, Department of Dairy Science
The Pennsylvania State University, University Park

Effects of level of glycerol and method of adding it, equilibration time, and addition of sugars to milk diluents, on the survival of spermatozoa after freezing, were studied. Heated and cysteine-treated homogenized milk and skimmilk diluents gave survival rates after freezing equal to those obtained with egg yolk–citrate diluent. Spermatozoa frozen in milk diluents maintained higher motility after thawing and storage at + 5° C. than those frozen in egg yolk–citrate. In skimmilk diluent, prefreezing glycerol equilibration periods of 30 min. and 4 hr. resulted in spermatozoan survival equal to or better than 18 hr. Adding 1.25% fructose to a skimmilk diluent resulted in a significant increase in freezability of bull spermatozoa as compared to untreated controls. *Editor.*

Most of the research on freezing bovine spermatozoa has involved a combination of glycerol and egg yolk–citrate diluent, but several reports have appeared on frozen semen involving glycerol in combination with various milk diluents. Erickson *et al. (5)* and Mixner and Saroff *(9)* found 10% glycerol to be the optimum level for use in heated homogenized milk, whereas Jones *et al. (7)* recently reported that 7% was best. For heated skimmilk diluent, an early report from this station *(11)* indicated a requirement of from 10 to 13% glycerol, in contrast to reports of 7.5% by Mixner and Saroff *(9)* and 8% by O'Dell and Hurst *(10)*.

With heated skimmilk, O'Dell and Almquist *(11)* found no significant differences in sperm survival after freezing among glycerol equilibration periods of 0.5, 4, and 18 hr. O'Dell and Hurst *(10)* compared glycerol equilibration times of 0.5 and 18 hr. for semen diluted in heated skimmilk and found a significant difference in favor of the shorter time.

In connection with research at this station on milk diluents for bovine semen, studies were initiated in 1953 to determine the usefulness of these diluents for freezing semen. The results reported here include studies on the effects of level of glycerol, method of adding glycerol, equilibration period, and the addition of sugars to milk diluents on the survival of bovine spermatozoa after freezing.

EXPERIMENTAL PROCEDURE AND RESULTS

As soon as possible after collection, the semen was partially diluted to 30 million motile spermatozoa per milliliter and cooled to 5° C. over a 3- to 4-hr.

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period. Final dilution was achieved by adding, in five equal portions at 6-min. intervals, an equal volume of diluent containing twice the desired final concentration of glycerol. The final diluted semen contained 1,000 units each of penicillin and streptomycin and 15 million motile spermatozoa per milliliter. Unless otherwise indicated, an 18-hr. equilibration period was allowed before freezing. In Experiments 1, 2, and 3, 1-ml. portions of diluted semen were put into 75 by 10 mm. Pyrex test tubes, and sealed with cork stoppers and adhesive tape. In Experiments 4 and 5, the samples were placed in 1.6-ml. glass ampules and sealed with an oxygen-propane gas flame. The semen samples were frozen in an ethyl alcohol bath by the gradual addition of dry ice and were thawed in either a 5 or 40° C. water bath. Duplicate spermatozoan motility estimations were made from each tube immediately after thawing and were averaged for use in statistical analysis. The ampules were coded to aid in reducing bias on the part of the observer.

The interaction between treatments and storage intervals was significant only in Experiment 4. Therefore, the tables for the other experiments (Tables 1, 2, and 4) were prepared using an average of the percentages of motile spermatozoa observed immediately after freezing and those observed after storage at −79° C.

Experiment 1. A factorial experiment was designed to determine the effect of diluters and levels of glycerol on the survival of bull spermatozoa frozen to −79° C. The following diluters were tested: *(a)* skimmilk heated at 92° C. for 10 min.; *(b)* skimmilk treated with 1 mg. of cysteine hydrochloride per milliliter of diluent; *(c)* heated homogenized milk; *(d)* cysteine-treated homogenized milk; *(e)* 1:3 egg yolk–citrate, in which the egg yolk was contained in the nonglycerol fraction only; and *(f)* 1:4 egg yolk–citrate, in which the egg yolk was present in both the nonglycerol and glycerol fractions. Each diluter was tested with 7, 10, and 13% glycerol by volume. The 18 treatments were evaluated with a total of 10 ejaculates, representing eight different bulls. Duplicate tubes of semen from each experimental diluent were frozen at the following rate: 1° C. per minute from +5 to −15° C. and rapidly (10 to 15° C. per minute) from −15 to −79° C. One tube of each pair was thawed immediately after freezing, whereas the remaining tube was stored at −79° C. for one week before examination. After thawing, the semen samples were maintained at 5° C. and motility estimated after 24 and 48 hr. of storage.

The results of this experiment are presented (Table 1). Analysis of variance showed a highly significant interaction between diluents and glycerol levels ($P < 0.01$). The skimmilk diluents containing 7% glycerol and the egg yolk diluents with 13% glycerol showed highly significantly ($P < 0.01$) poorer motility after freezing than the other treatments. Although slightly higher results were obtained with 10% glycerol in homogenized milk, the differences among the three glycerol levels were not significant. These results show that spermatozoa freeze equally as well in milk diluents as in egg yolk–citrate.

A highly significant difference ($P < 0.01$) in favor of milk diluters was found in the ability of spermatozoa to maintain motility during storage at +5° C.

TABLE 1

Effect of glycerol level on the survival of bull spermatozoa frozen in various diluents
(Mean % motile sperm in ten ejaculates)

Diluent	7% Glycerol	10% Glycerol	13% Glycerol	Post-thawing storage at 5° C. for: 0 hr.	24 hr.	48 hr.
Heated skimmilk	37	44	46	42	37	32
Cysteine-treated skimmilk	41	44	48	44	38	33
Heated homogenized milk	43	45	41	43	38	32
Cysteine-treated homogenized milk	43	44	42	43	39	36
Yolk-citrate 1:3	44	45	34	41	17	11
Yolk-citrate 1:4	45	46	38	43	21	14

post-thawing. Table 1 shows that semen frozen in milk diluters declined only 7 to 11 percentage units during 48 hr. of storage at +5° C.; whereas, semen frozen in egg yolk–citrate diluters declined approximately 30 percentage units.

Experiment 2. To test the effect of varying equilibration times and glycerol levels on the freezability of bull spermatozoa, a factorial experiment was designed involving two equilibration times (0.5 and 18 hr.), two glycerol levels (7 and 13% by volume), and two diluters (1:3 egg yolk–citrate and heated skimmilk). The semen samples were frozen in duplicate tubes at the following rates: 0.8° C. per minute from +5 to −10° C.; 1° C. per minute from −10 to −15° C.; 1.5° C. per minute from −15 to −20° C.; 2° C. per minute from −20 to −35° C., and 4 to 5° C. per minute from −35 to −79° C. One sample was thawed and examined immediately after freezing, whereas the other was stored at −79° C. for 48 hr.

Results of this experiment are shown (Table 2) and represent a mean of ten ejaculates. Analysis of variance revealed a highly significant interaction ($P < 0.01$) between diluents and equilibration times, as well as between diluents and glycerol levels. No interaction was found between equilibration time and glycerol level. With 1:3 yolk-citrate, an equilibration period of 18 hr. gave significantly higher percentages of motile sperm after freezing than a period of 0.5 hr. There was no difference between the 0.5- and 18-hr. equilibration periods with heated skimmilk. As an Experiment 1, in this study the 13%

TABLE 2

Effect of glycerol equilibration time and glycerol level on the percentages of motile spermatozoa surviving freezing to −79° C.
(Mean % motile sperm in semen of ten bulls)

Diluent	Per cent glycerol		Motile sperm after equilibration for: 0.5 hr.	18 hr.	Av.
				(%)	
Heated skimmilk	7		44	40	42
	13		45	46	45
		Av.	44	43	
Yolk-citrate 1:3	7		36	41	38
	13		32	38	35
		Av.	34	40	

glycerol level in heated skimmilk gave better sperm survival after freezing than the 7% level, whereas 7% was best for spermatozoa frozen in 1:3 yolk-citrate.

Experiment 3. Four methods of adding glycerol to the partially diluted and cooled semen were tested by freezing one ejaculate from each of ten bulls. Ten % glycerol by volume was used, and duplicate samples were frozen at the same rate as in Experiment 2. One sample was thawed and examined immediately after freezing, and the other was stored for 48 hr. at −79° C. before examination. By averaging these two observations, the percentages of motile spermatozoa were as follows:

Adding glycerol-skimmilk solution all at one time	39
Three equal additions at 10-min. intervals	41
Five equal additions at 6-min. intervals	42
Five equal additions at 12-min. intervals	42

The differences among the three methods of stepwise addition of the glycerol-skimmilk solution were not significant. However, these methods were significantly ($P < 0.05$) superior to addition all at once.

Experiment 4. The addition of sugar to egg yolk–citrate diluent has been reported to improve freezability of spermatozoa and permit freezing soon after addition of glycerol *(1, 3, 13)*. Therefore, a 4×4 factorial experiment was designed to study the effect of the addition of sugars to heated skimmilk diluent on the freezability of spermatozoa equilibrated for 0.5, 4, 8, and 16 hr. The following sugars were incorporated in the diluent by adding 2.5% (wt/vol) in the glycerol fraction: *(a)* none; *(b)* 1.25% of arabinose; *(c)* 1.25% of glucose, and *(d)* 1.25% of fructose. Thirteen % glycerol by volume was used and duplicate samples were frozen at the following rate: 3° C. per minute from +5 to −15° C.; 10° C. per minute from −15 to −50° C., and, rapidly (approximately 20° C. per minute) from −50 to −79° C. One ampule of each treatment was stored at −79° C. for ten days.

The results of this experiment are shown (Table 3) and represent a mean of ten ejaculates from six bulls. Analysis of variance showed that the addition of 1.25% fructose to heated skimmilk permitted a significantly ($P < 0.05$) higher survival of spermatozoa after freezing than when no sugar was added.

TABLE 3

Effect of various sugars and equilibration times on the survival of spermatozoa frozen to −79° C. in heated skimmilk diluent
(Mean of ten ejaculates)

Sugar	Motile sperm after equilibration for:					Motile sperm after storage at −79° C. for:	
	0.5 hr.	4 hr.	8 hr.	16 hr.	Av.	0 day	10 days
	(%)						
None	41	40	38	32	38	42	34
Arabinose	43	41	41	39	41	43	39
Glucose	43	42	42	37	41	43	39
Fructose	46	44	44	39	43	45	41
Av.	43	42	41	37	41	43	38

The values obtained for glucose and arabinose were slightly, but not significantly, higher than those obtained when no sugar was added. The interaction between sugars and equilibration periods was not significant. In heated skimmilk, improved freezability was obtained with equilibration periods of less than 16 hr. in the untreated controls, as well as in the samples containing added sugar. Regardless of treatment, the percentages of motile spermatozoa observed in samples frozen after 0.5, 4, and 8 hr. of equilibration were significantly ($P < 0.05$) higher than those obtained after 16 hr. of equilibration. Samples frozen within 0.5 hr. after the addition of glycerol showed the highest motility after freezing. This substantiates the results presented in Experiment 2.

A highly significant ($P < 0.01$) interaction between sugars and storage intervals at −79° C. (none *vs.* ten days) was found. There was less deterioration during storage at −79° C. for ten days in the samples containing added sugar than in the untreated controls.

Experiment 5. This experiment was designed to investigate the effect of the addition of fructose on the level of glycerol required for optimum freezability of spermatozoa in heated skimmilk. Glycerol levels of 7, 10, and 13% were tested in combination with 0.0, 0.5, 1.0, 1.5, and 2.0% by weight of fructose. Duplicate samples of each treatment were frozen after 6 hr. of equilibration at the same rate as in Experiment 4.

Table 4 presents the results of this trial and represents a mean of ten ejaculates. Spermatozoan survival after freezing in samples containing 10 and 13% glycerol was highly significantly ($P < 0.01$) superior to that observed with 7% glycerol. Thus, the addition of fructose did not reduce the requirement of 10 to 13% glycerol (found in Experiments 1 and 2) for maximum freezability of spermatozoa in heated skimmilk. Regardless of glycerol level, there was a highly significant ($P < 0.01$) difference among the motilities observed after freezing, in samples containing the different levels of fructose. Based on the least significant difference between means, significantly ($P < 0.01$) higher percentages of motile spermatozoa after freezing were obtained with samples containing 0.5 and 1.0% fructose than with samples containing 0.0 and 2.0% fructose. The differences among the other levels of fructose were not significant.

TABLE 4

Effect of glycerol and fructose levels on the survival of spermatozoa frozen to −79° C. in heated skimmilk diluent

(Mean of ten ejaculates)

	Motile sperm			
Fructose	7% Glycerol	10% Glycerol	13% Glycerol	Av.
		(%)		
0.0	39	47	44	43
0.5	43	49	49	47
1.0	44	46	50	47
1.5	43	48	46	45
2.0	39	44	47	43
Av.	42	47	48	

DISCUSSION

These results show that bull spermatozoa can be frozen equally as well in milk diluents as in an egg yolk–citrate diluent. In these experiments, the level of glycerol giving highest survival of spermatozoa after freezing varied with the diluent employed. Best results were obtained with 10% glycerol in homogenized milk and from 7 to 10% in egg yolk–citrate. These findings are in general agreement with those of other workers *(2, 5, 8, 9, 12)*. However, with skimmilk, 10 to 13% glycerol was required for optimum freezability, which is higher than the 7.5-8% levels reported by two other stations *(9, 10)*. Studies in progress at this station indicate that, as the level of total solids in a skimmilk diluent increases, the level of glycerol required for optimum freezability also increases. Thus, variations in the level of glycerol reported as optimum by different investigators can not be accurately evaluated unless the composition of the skimmilks is known. In Experiment 1 it was found that spermatozoa frozen in milk diluents were capable of maintaining a significantly higher percentage of motility after thawing and storage at +5° C. for two days than those frozen in egg yolk–citrate. The rapid loss in viability of spermatozoa after freezing and thawing may be related to the lower fertility results obtained with frozen semen.

Elimination of the glycerol equilibration period would decrease the total time required for processing frozen semen and might improve survival, by reducing the time during which the spermatozoa are motile prior to freezing. In these studies, a 0.5 hr. equilibration period with heated skimmilk gave equally as good, or better, sperm survival than longer periods of from 4 to 18 hr. These results need to be substantiated by fertility trials. Williams *(14)* has presented data showing that the fertility of semen diluted in homogenized milk and frozen after 6 hr. of equilibration was slightly higher than that obtained with portions of the same ejaculates frozen after equilibration for 18 hr.

It has been reported that glucose *(13)*, arabinose *(4)*, and fructose *(6)* increase the freezability of bull spermatozoa in egg yolk–citrate diluent. Upon testing these three sugars in a skimmilk diluent, it was found that fructose was the only one resulting in a significant increase in freezability of bull spermatozoa. Elliott *et al. (3)* have reported that the addition of fructose to egg yolk–citrate diluent improved the freezability of spermatozoa when no equilibration period was provided. In the present studies with heated skimmilk, a progressive improvement in freezability of spermatozoa with shorter equilibration periods was observed in the untreated control samples, as well as in those containing added sugar. Thus, the improved freezability obtained by adding sugar to skimmilk diluent was not related to the length of the equilibration period.

SUMMARY

The effects of level of glycerol, method of adding glycerol, equilibration period, and the addition of sugars to milk diluents on the survival of bovine spermatozoa after freezing have been studied. Heated and cysteine-treated homogenized milk and skimmilk diluents gave survival rates after freezing

equal to those obtained with egg yolk–citrate diluent. With homogenized milk, 10% glycerol by volume gave slightly higher survival rates than 7 or 13% glycerol. With skimmilk, 10 to 13% was required, whereas with egg yolk–citrate, better results were obtained with 7 and 10% glycerol. Spermatozoa frozen in milk diluents maintained a higher ($P < 0.01$) percentage motility after thawing and storage at +5° C. than spermatozoa frozen in egg yolk–citrate.

The stepwise addition of glycerol to semen diluted and frozen in heated skimmilk gave slightly better post-thawing motility than adding the glycerol all at one time. In skimmilk diluent, prefreezing glycerol equilibration periods of 30 min. and 4 hr. resulted in spermatozoan survival equal to or better than 18 hr. Equilibration time was not related to the level of glycerol present in the diluent.

The addition of 1.25% fructose to a skimmilk diluent resulted in a significant ($P < 0.05$) increase in freezability of bull spermatozoa, as compared to the untreated controls. However, the addition of sugar had no effect on the equilibration period or level of glycerol needed for optimum freezability. The addition of sugar resulted in higher percentages of motile spermatozoa following storage at −79° C. for ten days than samples without added sugar.

REFERENCES

(1) Blackshaw, A. W. The Effect of Equilibration and the Addition of Various Sugars on the Revival of Spermatozoa from −79° C. *Australian Vet. J.*, **31**: 124. 1955.

(2) Cragle, R. G., Myers, R. M., Waugh, R. K., Hunter, J. S., and Anderson, R. L. The Effects of Various Levels of Sodium Citrate, Glycerol, and Equilibration Time on Survival of Bovine Spermatozoa After Storage at −79° C. *J. Dairy Sci.*, **38**: 508. 1955.

(3) Elliott, F. I., Elliott, E. J., and Hafs, H. D. Current Results with Frozen Semen. p. 200. *Proc. 7th Ann. Conv. National Association Artificial Breeders.* Harrisburg, Pa. 1954.

(4) Emmens, C. W., and Blackshaw, A. W. The Low-Temperature Storage of Ram, Bull, and Rabbit Spermatozoa. *Australian Vet. J.*, **26**: 226. 1950.

(5) Erickson, W. E., Graham, E. F., and Frederick, E. C. The Effect of Antibiotics, Levels of Glycerol, and Rates of Freezing on Revival Rate of Bovine Spermatozoa in Yolk-Citrate and Milk Extenders. *J. Dairy Sci.*, **37**: 651. 1954.

(6) Hafs, H. D., and Elliott, F. I. The Effect of Methods of Adding Egg Yolk and Monosaccharides on the Survival of Frozen Bull Spermatozoa. *J. Dairy Sci.*, **38**: 811. 1955.

(7) Jones, W. M., Perkins, J. R., and Seath, D. M. The Effect of Glycerol Level and Rate of Freezing, for Various Extenders, on the Survival of Bovine Spermatozoa Frozen and Stored at −79° C. *J. Dairy Sci.*, **39**: 1574. 1956.

(8) Miller, W. J., and VanDemark, N. L. The Influence of Glycerol Level, Various Temperature Aspects, and Certain Other Factors on the Survival of Bull Spermatozoa at Subzero Temperatures. *J. Dairy Sci.*, **37**: 45. 1954.

(9) Mixner, J. P., and Saroff, Jack. Interference by Glycerol with Differential Staining of Bull Spermatozoa as Used with Semen Thawed from the Frozen State. *J. Dairy Sci.*, **37**: 1094. 1954.

(10) O'Dell, G. D., and Hurst, Victor. The Effect of Glycerol Equilibration Time on the Freezing of Bovine Spermatozoa in Egg Yolk–Sodium Citrate and Skimmilk Semen Extenders. *J. Dairy Sci.*, **39**: 1156. 1956.

(11) O'DELL, W. T., AND ALMQUIST, J. O. Techniques for Freezing Bull Spermatozoa in Heated Milk and Preliminary Breeding Results. *J. Dairy Sci.*, **37**: 652. 1954.

(12) SAROFF, JACK, AND MIXNER, J. P. The Relationship of Egg Yolk and Glycerol Content of Diluters and Glycerol Equilibration Time to Survival of Bull Spermatozoa After Low Temperature Freezing. *J. Dairy Sci.*, **38**: 292. 1955.

(13) VANDEMARK, N. L., AND KINNEY, W. C., JR. Procedure Used in Freezing Bull Semen. p. 192. *Proc. 7th Ann. Conv. National Association Artificial Breeders.* Harrisburg, Pa. 1954.

(14) WILLIAMS, J. A. Preliminary Report on Effect of Glycerol Equilibration Time on the Fertility of Frozen Bull Semen. p. 199. *Proc. 7th Ann. Conv. National Association Artificial Breeders.* Harrisburg, Pa. 1954.

FREEZING OF BOVINE SEMEN. II. EFFECT OF MILK SOLIDS LEVEL, GLYCEROL LEVEL, AND FRUCTOSE ON FREEZABILITY OF BULL SPERMATOZOA IN RECONSTITUTED AND FRESH SKIMMILK DILUENTS[1, 2, 3]

R. P. AMANN AND J. O. ALMQUIST

Dairy Breeding Research Center, Department of Dairy Science, The Pennsylvania State University, University Park

This investigation revealed that the level of glycerol required for optimum spermatozoan freezability was related to the total solids content of skimmilk diluents, and that 1.25% added fructose improved the post-thawing motility of spermatozoa frozen in reconstituted skimmilk. Reconstituted skimmilk gave optimum spermatozoan survival when the glycerol percentage by volume equalled the total solids percentage by weight, and when both were 9 or 11%. In fresh skimmilk containing 9% solids, 11% glycerol was significantly better than 9 or 13%. *Editor.*

A recent report from this station *(8)* cited levels of glycerol found by various workers to give optimum freezability of bovine spermatozoa in heated fresh skimmilk diluent. In egg yolk–citrate diluent, the optimum glycerol level for freezing bull semen has been found to be dependent both upon the concentration of egg yolk *(10)* and upon the concentration of sodium citrate *(3)* in the diluent. Saacke and Almquist *(9)* observed that altering the total solids content of skimmilk from 9 to 11% resulted in significantly decreased spermatozoan livability at +5° C. The fortification of skimmilk used for human consumption to approximately 10.5% total solids is a common commercial practice. Thus, it appears that the level of glycerol required for optimum spermatozoan freezability in skimmilk diluent may be influenced by the total solids content of the milk.

The inclusion of fructose in heated skimmilk and egg yolk–citrate diluents has been found to improve spermatozoan freezability *(1, 7, 8)*. Reconstituted (Instant Pet) nonfat dry milk solids were found by Johnson *et al. (4)* to provide a satisfactory diluent for storing bovine spermatozoa at +5° C. Use of powdered milk diluent for freezing semen would be especially advantageous in areas where good-quality fresh milk is difficult, or impossible, to obtain.

The present study was undertaken to determine, *(a)* if the level of glycerol required for optimum spermatozoan freezability is related to the total solids

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content of skimmilk diluent, and *(b)* if the addition of fructose would improve the post-thawing motility of bovine spermatozoa in reconstituted skimmilk diluent.

EXPERIMENTAL PROCEDURE

Fresh and reconstituted skimmilks were adjusted to various total solids levels and heated at 92 to 95° C. for 10 min. Throughout these trials, instant (Pet Milk Company) nonfat dry milk solids (NFDMS) were used to prepare the reconstituted skimmilk diluents. In Experiments 1 and 2, the total solids level of the skimmilks before heating was determined by the Mojonnier method. Freshly collected semen was partially diluted at room temperature to 30 million motile spermatozoa per milliliter in the heated skimmilk diluents. After cooling to +5° C., an equal volume of diluent containing twice the desired final concentration of glycerol was added in five equal portions at 10-min. intervals. The final glycerolated semen contained 15 million motile spermatozoa and 1,000 units each of penicillin and streptomycin per milliliter. In each experiment, a fresh commercial skimmilk which had been fortified with condensed skimmilk to a varying total solids content was tested simultaneously with 13% glycerol. During the 6-hr. equilibration period, 1.0-ml. portions of diluted semen were placed in 1.6-ml. glass ampules. The ampules of semen were frozen in a bath of ethyl alcohol by the gradual addition of crushed dry ice. The freezing rate was 3° C. per minute from +5 to −15° C., 10° C. per minute from −15 to −50° C., and approximately 12° C. per minute from −50 to −75° C.

The ampules of frozen semen were thawed in ice water immediately after freezing, or after ten days of storage at from −78 to −79° C. Duplicate estimations of the per cent of motile spermatozoa were made on each ampule and were averaged for use in statistical analysis. The ampules were coded and randomly selected for thawing, to aid in reducing observer bias.

The only interactions with storage intervals which were significant were those with either total solids levels or ejaculates. Since these interactions were of minor importance and did not change the over-all trends, the tables and figures were prepared by averaging the percentages of motile spermatozoa observed after zero and ten days of storage.

EXPERIMENTAL RESULTS

Experiment 1. NFDMS diluents were prepared with glass-distilled water at total solids levels of 9, 11, 13, and 15%, as follows:

Level of total solids	Weight of NFDMS	Volume of water
(%)	*(g.)*	*(ml.)*
9	27.8	272.2
11	34.1	265.9
13	40.2	259.8
15	46.4	253.6

Each of the reconstituted skimmilks was tested in a 4×4 factorial experiment at glycerol levels of 9, 11, 13, and 15% by volume. Diluent combinations of 9% solids–5% glycerol, 9% solids–7% glycerol, and 11% solids–7% glycerol also were tested. A different lot of NFDMS was used for each two of the ten ejaculates.

Results presented (Table 1) represent the mean motility for ten ejaculates from nine bulls. Analysis of variance showed a highly significant interaction ($P < 0.01$) between the total solids content of the skimmilk and the level of

TABLE 1

Effect of various levels of total solids and glycerol on the average motility of spermatozoa in reconstituted NFDMS diluents thawed after zero and ten days of storage at −79° C.

(Mean % motility of ten ejaculates)

Desired per cent total solids	Actual per cent total solids	Per cent glycerol						
		5	7	9	11	13[a]	15	Av.[b]
9	9.13 ± 0.04	28	35	39	39	26	10	28.4
11	11.24 ± 0.14		28	32	36	35	28	32.8
13	13.08 ± 0.12			23	26	32	29	27.6
15	15.13 ± 0.15			6	9	12	14	10.4
Av.				25.0	27.7	26.3	20.2	24.8

[a] Motility in fresh commercial skimmilk diluent (av. 9.86 ± 0.69% total solids) averaged 42%.

[b] Includes only the 9, 11, 13, and 15% glycerol levels.

glycerol required for optimum spermatozoan freezability. The highly significant solids level–glycerol level–ejaculate interaction was used as the error term for calculating the "F" value for the solids level–glycerol level interaction. There were no significant differences among the combinations of 9% solids–9% glycerol, 9% solids–11% glycerol, and 11% solids–11% glycerol, when tested by the least significant difference between means. With 13 and 15% solids diluents, the best results were obtained when the glycerol level was equal to the total solids level. For a given total solids level, post-thawing motility increased as the glycerol level approached the solids level (see Figure 1). Maximum motility was attained when the glycerol level was essentially equal to the total solids level; whereas, a further increase in the glycerol concentration resulted in reduced motility.

To define further the interaction of total solids and glycerol, the multiple regression technique was used to calculate an equation expressing this relationship. This equation, with the per cent of motile spermatozoa represented by Y, the total solids level represented by X_1, and the glycerol level by X_2, is as follows:

$$Y = +16.36X_1 + 1.574X_2 + 1.036X_1X_2 - 1.323X_1^2 - 0.6135X_2^2 - 51.19$$

Based on this equation, the optimum levels of total solids and glycerol in reconstituted NFDMS diluent were calculated to be 10.0% by weight and 9.7% by volume, respectively.

Experiment 2. This 4×3 factorial experiment was similar in design to Experiment 1, except that fresh skimmilk obtained directly from a separator

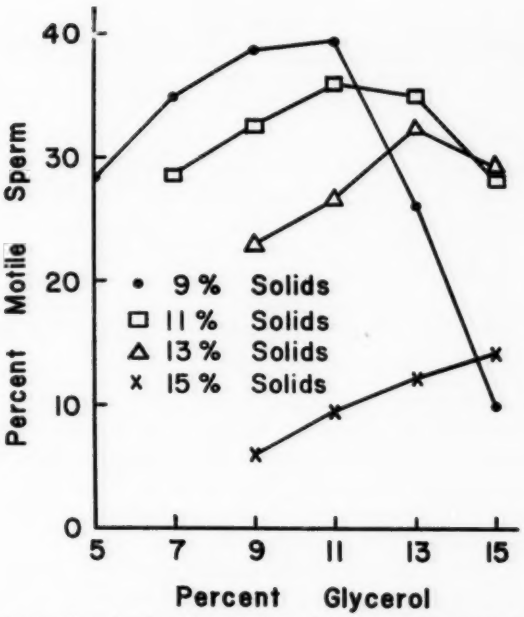

FIG. 1. Effect of various total solids and glycerol levels on the average motility of spermatozoa thawed after zero and ten days of storage at −79° C., in reconstituted NFDMS diluents.

was used, rather than NFDMS. The solids level of four lots of fresh skimmilk was adjusted with condensed skimmilk or distilled water. Diluents tested were unaltered fresh skimmilk and fresh skimmilk adjusted to 9, 11, and 13% total solids. Glycerol levels of 9, 11, and 13% were used with the unaltered skimmilk and with each of the three solids levels. Additional combinations, consisting of 7% glycerol with 9 and 11% solids, and 15% glycerol with 11 and 13% solids skimmilk, were tested.

The mean percentages of motility for ten ejaculates from eight bulls are presented (Table 2). Analysis of variance of the basic 4×3 factorial experiment showed a highly significant interaction between the level of total solids and the level of glycerol in fresh skimmilk diluent. The interaction among ejaculates, solids levels, and glycerol levels was significant.

The relationship between solids and glycerol levels in fresh skimmilk is illustrated (Figure 2). At each solids level, as the glycerol concentration was increased, post-thawing spermatozoan motility also increased. However, maximum freezability in fresh skimmilk was not attained until the glycerol level exceeded the total solids level. An increase in glycerol concentration above its optimum level resulted in decreased spermatozoan motility only in the 9% solids diluent.

Nine per cent solids diluent with 11% glycerol was significantly ($P < 0.05$) better than with 9% glycerol, and highly significantly better than with 13% glycerol. In unaltered skimmilk, 11% glycerol gave highly signifi-

TABLE 2

Effect of various levels of total solids and glycerol on the average motility of spermatozoa in fresh skimmilk diluents thawed after zero and ten days of storage at −79°C.
(Mean % motility of ten ejaculates)

Desired per cent total solids	Actual per cent total solids	Per cent glycerol					
		7	9	11	13[a]	15	Av.[b]
Unaltered	9.02 ± 0.04		36	40	32		35.8
9	9.01 ± 0.03	30	35	39	33		35.7
11	10.94 ± 0.06	26	32	38	38	39	36.1
13	13.00 ± 0.11		15	20	23	28	19.2
Av.			29.6	33.8	31.8		31.7

[a] Motility in fresh commercial skimmilk diluent (av. 9.50 ± 0.71% total solids) averaged 34%.

[b] Includes only the 9, 11, and 13% glycerol levels.

cantly greater motility than 9 or 13% glycerol. With 11% solids diluent, there was no significant difference between 11 and 13% glycerol. Although 13% solids skimmilk gave highly significantly poorer freezability than the three other diluents tested, it responded best with 15% glycerol. There were no significant differences among unaltered and 9% solids skimmilks with 11% glycerol, and 11% solids skimmilk with 11 or 13% glycerol.

Experiment 3. Reconstituted NFDMS skimmilks were prepared to contain 9 and 11% total solids and each was tested with 9 and 11% glycerol. Fructose

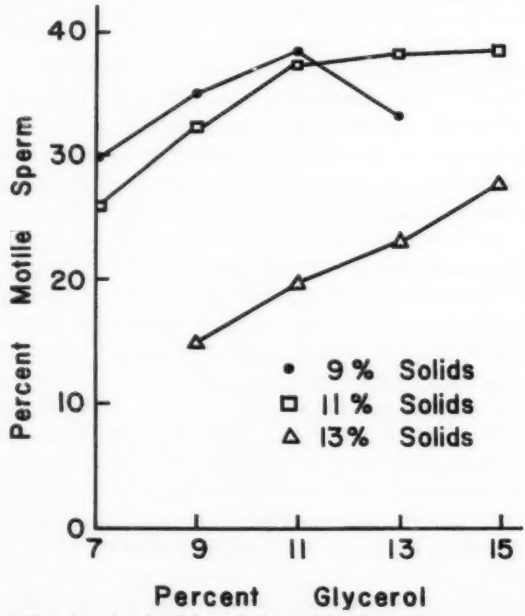

FIG. 2. Effect of various total solids and glycerol levels on the average motility of spermatozoa thawed after zero and ten days of storage at −79° C., in fresh skimmilk diluents.

was added to each of the four diluents at levels of 0.00 and 1.25% (w/v) by dissolving twice the desired final concentration in the glycerol fraction of the diluent. A different lot of NFDMS was used for each two of the 12 ejaculates frozen.

The mean percentages of motile spermatozoa after zero and ten days of storage are presented (Table 3). Analysis of variance showed that the addition of fructose to reconstituted NFDMS diluents resulted in a highly significant increase in post-thawing motility. The solids level–glycerol level–fructose level interaction also was highly significant, although the differences were small. With 9% solids–11% glycerol diluent there was a highly significant increase in post-thawing motility when fructose was present, and with 11% solids–9% glycerol diluent, the increase approached significance at the 5% level. There were no significant differences among the four diluents containing fructose, except that 9% solids–11% glycerol was significantly better than 9% solids–9% glycerol. Among the diluents without fructose, 11% solids–11% glycerol was highly significantly better than the three other combinations. When the fresh commercial skimmilk diluent contained fructose, it was highly significantly better than any other diluent. The ejaculate variation in response to the solids level–fructose level and the glycerol level–fructose level interactions was small but significant.

TABLE 3

Effect of fructose on the average motility of spermatozoa in reconstituted NFDMS diluents thawed after zero and ten days of storage at −79° C.

(Mean % motility of 12 ejaculates)

Diluent	0.00% Fructose	1.25% Fructose	Difference
Fresh commercial skimmilk	37	46	+9
9% solids			
9% glycerol	33	35	+2
11% glycerol	31	38	+7
11% solids			
9% glycerol	33	35	+2
11% glycerol	36	37	+1
Av.	33.3	36.3	+3.0

In all experiments, the decrease in post-thawing motility during ten days of storage at −79° C. was highly significant. In Experiments 1, 2, and 3, this decline averaged eight, seven, and eight percentage units, respectively. In Experiment 3, the loss in motile spermatozoa was not reduced by the presence of fructose in the NFDMS diluent.

Other experiments have been conducted in this laboratory to determine the effect of adding 1.25% fructose to fresh commercial skimmilk diluent on spermatozoan freezability *(8)*. These data have been combined with those from the present study to provide information on 32 ejaculates from 23 bulls. The average post-thawing motility in the fresh commercial skimmilk diluent containing fructose was 47%, as compared to 41% without fructose. The difference between the standard deviations for the motility of the ejaculates frozen with and without fructose (6.2 *vs.* 10.3) was highly significant.

DISCUSSION

The data presented show that the level of glycerol required for optimum spermatozoan freezability in heated skimmilk diluent is dependent upon the total solids content of the milk. In heated reconstituted skimmilk diluent, best results were obtained when the total solids (w/w) and glycerol (v/v) levels were in a 1:1 ratio. The optimum composition for NFDMS diluent, as calculated by multiple regression of 10.0% total solids and 9.7% glycerol, is in agreement with the recent findings of Bruce *(2)*.

With fresh skimmilk diluent, a slightly different relationship between solids and glycerol levels was found. Experiment 2 showed that the glycerol level in fresh skimmilk diluent should be approximately two percentage units (v/v) higher than the percentage of total solids (w/w). This finding substantiates previous work at this station, in which 10 to 13% glycerol gave maximum spermatozoan survival in fresh skimmilk diluent *(6, 7, 8)*.

The data in Experiment 1 indicate that bovine spermatozoa can be frozen in heated reconstituted nonfat dry milk solids diluent equally as well as in fresh skimmilk diluent. In this laboratory, a total of 53 ejaculates, representing 29 bulls, has been frozen in both heated 9% solids NFDMS–9% glycerol diluent and in heated fresh commercial skimmilk containing either 11 or 13% glycerol. The average percentages of motile spermatozoa upon thawing, after zero and ten days of storage in these two diluents, were 35.8 and 36.4% respectively.

It is apparent from the current studies that the total solids content of the skimmilk used should be determined, if optimum spermatozoan motility after thawing is desired. Furthermore, recommendations for glycerol levels used in skimmilk should be accompanied by total solids data for the milk used.

The finding that with both fresh and reconstituted skimmilks the glycerol level must be increased as the total solids level increases is similar to observations of Saroff and Mixner *(10)* with egg yolk–citrate diluent. These results make tenable the postulate that the solids in a diluent, either egg yolk solids *(10)* or colloidal milk solids, tie up a portion of the glycerol. Although not demonstrated in the present study, the increased glycerol requirement with increasing solids levels might also be attributed to an increase in the electrolyte concentration in the diluent. Johnson *et al. (4)* observed that bovine spermatozoa were very sensitive to changes in the electrolyte concentration of reconstituted NFDMS diluent when stored at +5° C. Lovelock *(5)* postulated that the beneficial action of glycerol during freezing is due in part to its action as a salt buffer, which prevents the formation of a lethal concentration of electrolyte. Thus, it is possible that increased glycerol requirement with fortified skimmilk results from the increase in both total solids and electrolytes.

The over-all effect of adding fructose to NFDMS diluent was to increase post-thawing motility by three percentage units. This beneficial effect appeared to be greater when the solids to glycerol ratio was altered from the 1:1 ratio found to be optimum in Experiment 1. There also appeared to be a reduction in the variability among ejaculates in response to the solids-glycerol interaction.

SUMMARY

The relationship between the total solids and glycerol levels was studied in heated reconstituted instant NFDMS and in heated fresh skimmilk diluents. Heated, reconstituted NFDMS diluent gave spermatozoan freezability equal to that in heated, fresh skimmilk diluent.

In reconstituted skimmilk there was a highly significant interaction ($P < 0.01$) between the level of total milk solids and the level of glycerol required for optimum post-thawing spermatozoan motility. Optimum motility was obtained when the percentage of glycerol (by volume) was equal to the percentage of total solids (by weight) and when both levels were 9 or 11%.

In fresh skimmilk containing 9% solids, it was found that 11% glycerol was significantly better than 9 or 13%. However, when the skimmilk had been fortified with condensed skimmilk to 11% solids, the use of 13 or 15% glycerol gave slightly better results. Comparable freezability was obtained with heated skimmilk diluents containing either 9 or 11% solids when the proper level of glycerol was used. Thus, for optimum spermatozoan motility after thawing, it is essential to ascertain the approximate total solids content of the skimmilk diluent.

The addition of 1.25% fructose to NFDMS diluents resulted in a highly significant increase in post-thawing motility and reduced the variation among ejaculates in spermatozoan survival.

REFERENCES

(1) Blackshaw, A. W. The Effect of Equilibration and the Addition of Various Sugars on the Revival of Spermatozoa from −79° C. *Australian Vet. J.*, **31**: 124. 1955.

(2) Bruce, W. The Application of the Low Temperature Storage of Bull Semen for Artificial Insemination. p. 27, *Proc. IIIrd Intern. Congr. Animal Reproduction, Sec. III.* Cambridge. 1956.

(3) Cragle, R. G., Myers, R. M., Waugh, R. K., Hunter, J. S., and Anderson, R. L. The Effects of Various Levels of Sodium Citrate, Glycerol, and Equilibration Time on Survival of Bovine Spermatozoa After Storage at −79° C. *J. Dairy Sci.*, **38**: 508. 1955.

(4) Johnson, P. E., Flipse, R. J., and Almquist, J. O. Diluters for Bovine Semen. VIII. The Effects of Alterations of Some Physical Factors of a Milk Diluter on the Livability of Bull Spermatozoa. *J. Dairy Sci.*, **39**: 180. 1956.

(5) Lovelock, J. E. The Mechanism of the Protective Action of Glycerol Against Haemolysis by Freezing and Thawing. *Biochim. et Biophys. Acta*, **11**: 28. 1953.

(6) Marsh, L. A. The Effect of Glycerol Level, Equilibration Time, and Freezing Rate on the Freezability of Bovine Spermatozoa. M.S. thesis, The Pennsylvania State University. 1955.

(7) O'Dell, W. T., and Almquist, J. O. Techniques for Freezing Bull Spermatozoa in Heated Skimmilk and Preliminary Breeding Results. *J. Dairy Sci.*, **37**: 652. 1954.

(8) O'Dell, W. T., and Almquist, J. O. Freezing Bovine Semen. I. Techniques for Freezing Bovine Spermatozoa in Milk Diluents. *J. Dairy Sci.*, **40**: 1534. 1957.

(9) Saacke, R. G., and Almquist, J. O. The Effect of Heated Fortified Skimmilks upon the Livability of Bovine Spermatozoa. *J. Dairy Sci.*, **38**: 1046. 1955.

(10) Saroff, J., and Mixner, J. P. The Relationship of Egg Yolk and Glycerol Content of Diluters and Glycerol Equilibration Time to Survival of Bull Spermatozoa After Low Temperature Storage. *J. Dairy Sci.*, **38**: 292. 1955.

CRIMPED OATS FOR DAIRY CATTLE[1]

R. B. BECKER, P. T. DIX ARNOLD, AND J. M. WING
Dairy Science Department

AND

J. T. McCALL AND G. K. DAVIS
Department of Animal Husbandry and Nutrition
University of Florida, Gainesville

The mechanical utilization of crimped oats by calves, heifers, and cows was studied. The losses of crimped oats fed were 0.77%, or less. These results favor their use in coarse-textured feeds for dairy cattle. *Editor.*

The preparation of grains affects their utilization and feeding value. Whole grains and coarsely ground grains usually are more palatable than the same kinds ground finely. More preparation is required for small, hard seeds (kafirs) than for large seeds. There are many reports available concerning the preparation of corn and kafirs, but few trials have dealt with utilization of oats processed in different ways.

Schalk and Amadon *(8)* observed by means of rumen fistulas that about 50% of shelled corn was broken in mastication by a mature cow, but that whole oats entered the rumen practically intact. A bolus of grain soon disintegrated in the rumen. Grains that became enmeshed among the forages returned for rumination. Other kernels passed on intact.

Shaw and Norton *(9)* fed whole oats and collected droppings over seven days from six calves, six yearlings, and six cows. Some oats were washed through the screens. The daily offering per animal, and oats recovered from the feces, were:

	Daily offering *(lb.)*	Whole oats recovered *(%)*
Calves	2–3	2.98
Yearlings	6	5.48
Cows	11	12.06

Davis *et al. (3)* found crimped oats to yield 69.6% of total digestible nutrients, as compared with 68.4% for ground oats. Finely ground concentrates were not digested more efficiently than coarse-textured concentrates. Colovos *et al. (1)* later found values of 70.58 and 67.82% of total digestible nutrients for crimped and ground oats, respectively. Cows ate the coarse concentrates more rapidly than those ground finely.

McCandlish *(6)* observed that calves preferred shelled corn and whole oats to the same grains ground. Olson *(7, 10)* noted that coarsely ground corn and oats were more palatable to cows than these grains whole or finely ground. From 10.8 to 14.8% of whole oats was voided undigested.

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TABLE 1

Three groups of dairy cattle, and the total amount of crimped oats material voided during ten days

No.	Age	Body weight	Crimped oats voided in ten days[a]		Digested
	(Yr., mo., days)	*(lb.)*	*(g.)*	*(%)*	*(%)*
Calves					
133 X	0– 8– 13	335	24.52	0.27	
137 X	0– 8– 5	313	42.94	0.47	
138 X	0– 7– 27	324	17.05	0.19	
142 X	0– 7– 27	330	69.57	0.77	
Av.	0– 8– 4	326	38.52	0.43	99.57
Yearlings					
46 X	1– 6– 16	677	72.25	0.32	
50 X	1– 5– 28	594	38.95	0.17	
51 X	1– 5– 25	583	38.47	0.17	
52 X	1– 5– 6	624	36.78	0.16	
Av.	1– 5– 21	620	46.61	0.21	99.79
Cows					
566 F	5– 8– 27	955	104.78	0.46	
578 F	5– 9– 22	894	117.92	0.52	
595 F	5– 6– 17	838	99.14	0.44	
776 F	3– 11– 26	998	132.86	0.58	
Av.	5– 3– 13	921	113.68	0.50	99.50

[a] Each calf consumed 2 lb. daily of crimped oats; yearlings and cows, 5 lb. each, with free access to hay.

At the Texas Station *(2)*, cows produced more milk from ground than from whole grains in the feed.

Purdue workers *(5, 11)* found a few whole grains in feces from calves four to five months old. Cows voided 20 to 25% of whole oats; 1 to 2% of crushed oats, and negligible amounts of medium-ground oats.

Because a significant percentage of whole grains pass through older cattle undigested, Eckles *(4)* estimated that 10% of their value could be spent in preparation before feeding them to dairy cows. Wilbur *(11)* determined that not over 1 to 2% of crushed oats was found in the cow's feces.

This feeding trial was undertaken to determine the mechanical utilization of crimped oats by dairy animals of different ages.

METHODS

The recleaned Southern-grown oats used in the feeding trials had been tempered and crimped in a commercial feed mill. Two pounds of crimped oats were fed daily as the concentrate per calf, and 5 lb. for each yearling and cow.

Four calves were selected that were about 8 mo. old, weighing about 325 lb. each; four yearling heifers about 18 mo. old averaged 620 lb. in weight, and four Jersey cows averaged about 920 lb. Each animal was placed in a separate pen with free access to water, mineral supplement, and as much coarsely chopped Alyce clover hay as it would consume. Crimped oats and hay were supplied once daily. A ten-day preliminary feeding period was followed by a ten-day

TABLE 2

Composition of crimped oats before and after passage through the digestive tract of cattle

	Moisture	Crude protein	Ash	Ether extract	Crude Fiber	Nitrogen-free extract
	(%)					
Crimped oats	11.25	10.41	2.02	2.71	13.88	59.73
Groats	10.32	14.96	1.70	3.28	9.67	60.07
Oat hulls	9.26	2.67	3.40	0.43	35.60	48.64
	Crimped oats recovered from feces					
Calf No.						
133 X	11.66	8.94	3.27	3.72	19.96	52.45
137 X	12.10	7.04	4.27	2.92	26.79	46.88
138 X	11.58	9.77	3.00	4.49	17.70	53.46
142 X	10.89	7.81	3.81	3.02	10.18	54.29
Av.	11.56	8.39	3.59	3.54	21.16	51.76
Heifer No.						
46 X	9.60	7.00	3.41	3.64	21.25	55.10
50 X	10.65	7.34	3.28	2.47	23.04	53.22
51 X	10.74	8.41	2.94	3.46	19.16	55.29
52 X	11.05	9.24	2.75	4.26	18.07	54.63
Av.	10.51	8.00	3.10	3.46	20.38	54.55
Cow No.						
566 F	11.19	9.56	2.38	3.13	16.56	57.18
578 F	11.39	8.70	2.93	3.18	17.15	56.65
595 F	11.65	9.52	2.58	3.50	16.37	56.38
776 F	11.32	9.64	2.69	3.24	17.23	55.88
Av.	11.39	9.36	2.64	3.26	16.83	56.52

experimental period during which all feces were collected from the lot daily.

The feces of each animal were washed through one-half inch hardware cloth with water, and collected on a finer screen. Separations were made daily from total feces of each calf and yearling, and from 50% aliquot samples for each cow. Whole oats, groats, and oat hulls were picked manually from the fine screen. They were air-dried, weighed, and composited from each animal. The customary proximate feed analyses were determined on the original crimped oats, groats, oat hulls, and on the oat materials separated from the feces of each animal.

RESULTS

The recleaned crimped oats used in the three trials weighed 34 lb. per bushel. Two representative 50-g. samples averaged 66% groats and 34% hulls.

Eight-mo.-old dairy calves each consumed 2 lb. of crimped oats daily, along with a free-choice offering of chopped Alyce clover hay; whereas, the yearling heifers and dry cows each ate 5 lb. daily.

A very small proportion of the total feces was oats or parts of oat kernels. These included intact kernels and hull fragments. Part, and sometimes all, of the starchy contents of the groats had been digested. More hulls than groats were voided.

Earlier investigations on feeding whole grains to cattle had pointed to age, or amount of feed consumed daily, as a factor in the proportion of kernels un-

digested. The results of this investigation, however, did not point to age as an appreciable factor in utilization of crimped oats. Variations were observed between animals in each group. Although losses of oats were small in every instance, yearlings voided a smaller percentage than did the cows. One calf—142-X—voided more than other animals; 776-F was second highest, and 578-F was third among 12 animals.

On the basis of daily intake of oats per 100 lb. live weight, the heifers received 0.81 lb., calves, 0.61 lb., and cows, 0.54 lb. The proportion of losses can not be explained on the basis of offering as related to average body weight. Over 99.5% of the crimped oats was reduced in the digestive processes, so that the residues were not recognizable. It appeared that the physical phase of the digestion of crimped oats had been quite efficient.

CONCLUSION

The present work with calves, heifers, and cows showed the losses of crimped oats fed to be 0.77% or less. These results favor the use of crimped oats in coarse-textured feeds for dairy cattle, and substantiate the recommendation made by Colovos and coworkers *(1)*.

REFERENCES

(1) Colovos, N. F., Keener, H. A., Davis, H. A., Morrow, K. S., and Gibson, K. S. The Effect of Texture on the Nutritive Value of Concentrates for Dairy Cattle. New Hampshire Agr. Expt. Sta., *Bull.* 419. 1955.

(2) Darnell, A. L., and Copeland, O. C. Ground versus Unground Grain for Lactating Dairy Cows. Texas Agr. Expt. Sta., *Bull.* 530. 1936.

(3) Davis, R. F., Loosli, J. K., and Grippin, C. H. The Effect of Texture on the Digestibility of Oats and a Mixed Concentrate by Ruminants. *J. Animal Sci.*, 12: 913. 1953.

(4) Eckles, C. H. *Dairy Cattle and Milk Production.* 2nd ed. (revised). p. 479. Macmillan Co., New York. 1923.

(5) Hilton, J. H., Wilbur, J. W., and Hienton, T. E. The Value of Grinding Grains for Young Dairy Calves. Indiana Agr. Expt. Sta., *Bull.* 373. 1933.

(6) McCandlish, A. C. Appetite as a Guide in Feeding Dairy Calves. Iowa Agr. Expt. Sta., *Research Bull.* 51. 1919.

(7) Olson, T. M. The Effect of Fineness of Grinding Grain on Milk Production. S. Dakota Agr. Expt. Sta., *Bull.* 358. 1942.

(8) Schalk, A. F., and Amadon, R. S. Physiology of the Ruminant Stomach (Bovine). Study of the Dynamic Factors. N. Dakota Agr. Expt. Sta., *Bull.* 216. 1928.

(9) Shaw, R. S., and Norton, H. W., Jr. Feeding Whole Grains. Mich. Agr. Expt. Sta., *Bull.* 242. 1906.

(10) Wallis, G. C., and Olson, T. M. How Fine Should Feeds Be Ground for Milk Cows? S. Dakota Agr. Expt. Sta., *Circ.* 34. 1941.

(11) Wilbur, J. W. Grinding Grains for Dairy Cows. Indiana Agr. Expt. Sta., *Bull.* 372. 1933.

FEEDING VALUE OF CORN AND SORGHUM SILAGE FOR MILK PRODUCTION[1]

J. R. OWEN, J. T. MILES, W. C. COWSERT, J. W. LUSK, E. W. CUSTER, AND J. T. CARDWELL

Dairy Department, Mississippi State College, State College

Corn, and varieties of sorghum silage, were prepared from alternate plots in the same field. One double-reversal and two Latin-square feeding trials were conducted with from 22 to 27 cows, to compare them. Cows produced more milk, consumed more silage, and gained more weight on corn than on any variety of sorghum. Tracy sorghum imparted a stronger silage flavor to milk than did any of the other silages. *Editor.*

Sweet sorghum is one of the most important silage crops grown in the South, although its feeding value has been questioned. Good *et al. (6)* reported that, pound for pound, sorghum silage was only 72.2% as valuable as corn silage in fattening steers; however, when yields of the two crops were considered, sorghum was 92.2% as economical as corn. LaMaster and Morrow *(8)* concluded that sorghum was 72.17% as efficient as corn for milk production. Cunningham and Reed *(4)* and Nevens and Kendall *(10)* reported a slight advantage in milk production for corn silage over sorghum silage.

New varieties of sorghum (Sart and Tracy) have been developed recently *(13, 14)* and are being used widely throughout the South. Investigators *(1, 2, 3, 11)* have reported the yield per acre of these varieties of sorghum; however, little work has been reported concerning their feeding value. Ray and Thurman *(11)* reported less silage consumption by, and lower daily gains in, steers fed Sart sorghum than when fed either Tracy or Atlas sorghum. In these tests, the feeding values of Tracy and Atlas sorghum were about equal.

EXPERIMENTAL PROCEDURE

Three experiments were carried out during the years 1954–55, 1955–56, and 1956–57. Each year, Dixie 18 hybrid corn and one or more varieties of sorghum were grown in alternate strips in the same field. Cultural practices were the same for all crops, with the exception that an additional 33 lb. of nitrogen was used per acre on the corn. Silage was stored in upright concrete silos. Production cost per ton of stored silage was obtained on all crops.

In 1954–55, a double-reversal feeding trial involving 22 cows was used to compare silage made from corn and from Sart sorghum. Three 28-day test periods with 7-day changeover periods were used. In 1955–56, a Latin-square feeding trial with 27 cows was used to compare silages made from corn, Sart sorghum, and Tracy sorghum, and in 1956–57 the same design was used with

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24 cows to compare corn, Tracy sorghum, and Texas seeded-ribbon silages. Both of these trials involved three 21-day test periods and 7-day changeover periods. In each study, cows of the Jersey, Guernsey, and Ayrshire breeds were used.

Cows were fed silage ad libitum twice each day and 0.5 lb. of alfalfa hay per 100 lb. body weight once a day. Silage and hay consumption were recorded daily for all cows. Rate of concentrate feeding was adjusted weekly according to production of 4% milk during the previous week. Daily milk weights were recorded on all cows, and butterfat tests were determined weekly, on separate samples of milk obtained in the morning and evening milkings. Change in body weight was determined from an average of three consecutive daily weights, at the beginning and ending of each comparison period.

During the feeding trials in 1955–56 and 1956–57, samples of milk were obtained from each cow two or more times during each comparison period, to be scored for flavor. The samples were cooled immediately after being obtained, and refrigerated until scored. Flavor scores were determined by two experienced judges, using the official score-cards *(5)*.

RESULTS

Yield per acre and cost of stored silage per ton for each year are shown (Table 1). In 1954–55, the yield of Dixie 18 hybrid corn was 6.0 tons per acre, compared to 19.1 tons per acre of Sart sorghum. A severe drought seriously affected the yield of the corn; whereas, the sorghum withstood the drought and made considerable growth following late summer rains. The corn was ensiled on August 9 and the sorghum on October 6. The rainfall during the next two summers was more evenly distributed throughout the summer months and the difference in yield between crops was not so large.

Cost of stored silage was determined by the number of man- and equipment-hours used in producing the silage, actual cost of fertilizer and seed, and a charge of $10 per acre for rent of the land used. The year-to-year variation in cost was affected by the yield of silage per acre, and the amount of lodging of the crop, which slowed down the silage-cutting operation. The sorghum was lodged to some extent each year; however, the principal variation caused by lodging was on the corn, in 1956.

TABLE 1

Yield of corn and sorghum silage per acre, and cost of stored silage[a]

Year	Dixie 18 corn	Sart sorghum	Tracy sorghum	Texas seeded-ribbon
	(yield, acre)			
1954	6.0	19.1	.....	.....
1955	14.5	19.3	20.0	.....
1956	11.1	.....	20.9	28.0
	(cost, $)			
1954	8.19	5.20	.....	.....
1955	4.73	5.09	5.62	.....
1956	8.23	.....	4.89	3.61

[a] In tons.

TABLE 2
Average daily feed consumption, milk production, and body weight change on corn and sorghum silages

Crop	Hay	Grain	Silage	FCM	Weight change
			(lb.)		
		Experiment 1, 1954–55			
Dixie 18 corn	4.3	7.6	52.1	26.8	+0.41
Sart sorghum	4.4	7.0	48.1	24.5	−0.44
L.S.D. ($P < 0.01$)			2.22	1.29	0.70
		Experiment 2, 1955–56			
Dixie 18 corn	4.4	7.5	65.7	30.0	+0.08
Sart sorghum	4.5	7.1	54.1	27.0	−0.59
Tracy sorghum	4.6	6.9	55.9	27.4	−0.34
L.S.D. ($P < 0.01$)			2.8	1.24	0.53
		Experiment 3, 1956–57			
Dixie 18 corn	4.5	7.2	54.5	27.3	+0.64
Tracy sorghum	4.5	7.0	49.5	25.2	−0.16
Texas seeded-ribbon	4.7	6.6	47.4	23.5	−0.79
L.S.D. ($P < 0.01$)			3.11	1.20	0.64

Data on feed consumption, milk production, and change in body weight are shown (Table 2). Differences in hay fed were due to changes in body weight on the different types of silage fed. In the same manner, the amount of grain fed was based on the amount of milk produced. When analyzed, the differences in hay and grain consumption were significant; however, statistical data are not shown in Table 2, because the differences were small and were a reflection of change in body weight and level of milk production.

In each feeding trial, the differences in silage consumption, production of 4% FCM, and change in body weight were highly significantly ($P < 0.01$) in favor of corn silage over each variety of sorghum silage *(12)*. In Experiment 2, the differences between Sart and Tracy sorghums were not significant. In Experiment 3, the difference in milk production in favor of Tracy sorghum over Texas seeded-ribbon was highly significant ($P < 0.01$), and the difference in change in body weight on the two silages was significant ($P < 0.05$). The dif-

TABLE 3
Moisture and chemical composition of silages

Silage	Moisture	Crude protein	Crude fat	Crude fiber	Ash	N.F.E.
			(%)			
		Experiment 1, 1954–55				
Dixie 18 corn	74.31	1.72	0.46	7.64	1.13	14.74
Sart sorghum	75.67	1.05	0.46	7.08	1.52	14.22
		Experiment 2, 1955–56				
Dixie 18 corn	73.27	1.95	0.60	7.56	1.15	15.47
Sart sorghum	75.89	1.17	0.45	8.17	1.24	13.08
Tracy sorghum	73.07	1.21	0.49	8.12	1.05	16.06
		Experiment 3, 1956–57				
Dixie 18 corn	72.35	1.98	0.67	8.58	1.67	14.75
Tracy sorghum	70.16	1.55	0.75	9.12	1.66	16.76
Texas seeded-ribbon	75.74	1.27	0.54	8.49	1.39	12.57

TABLE 4

Daily feed cost and income per cow on different silages

Item	Corn	Sart	Tracy	Texas seeded-ribbon
		($)		
	Experiment 1, 1954–55			
Feed cost[a]	0.51	0.40	.....	.....
Value of milk[b]	1.34	1.22	.....	.....
Income above feed cost	0.83	0.82	.....	.....
Adjusted income above feed cost[c]	1.05	0.64	.....	.....
	Experiment 2, 1955–56			
Feed cost[a]	0.45	0.42	0.43	.....
Value of milk[b]	1.50	1.35	1.37	.....
Income above feed cost	1.05	0.93	0.94	.....
Adjusted income above feed cost[c]	1.09	0.68	0.79	.....
	Experiment 3, 1956–57			
Feed cost[a]	0.51	.....	0.40	0.35
Value of milk[b]	1.36	.....	1.26	1.18
Income above feed cost	0.85	.....	0.86	0.83
Adjusted income above feed cost[c]	1.21	.....	0.79	0.49

[a] Grain cost, $60 per ton; hay cost, $30 per ton; silage cost as shown in Table 1.
[b] Based on $5 cwt. Class I milk.
[c] Change in body weight converted to milk equivalent; 3.53 lb. TDN per lb. gain, 2.73 lb. TDN per lb. loss, and 0.32 lb. TDN per lb. FCM produced.

ference in silage consumption between the two varieties of sorghum in Experiment 3 was not significant.

The higher consumption of all silages in Experiment 2 than in Experiments 1 and 3 cannot be explained by the authors, unless it was that palatability of the silages was affected by more favorable climatic conditions during that growing season. Moisture and chemical compositions of the silages are shown (Table 3).

Data on feed cost and income per cow are shown (Table 4). The feed cost was higher in each experiment when cows were fed corn silage than when fed any variety of sorghum; however, on a Class I market, the value of the increased milk produced was equal to or exceeded the difference in feed cost. In addition, cows gained weight when fed corn silage and lost weight on each variety of sorghum. Since a change-over type design was used in each of the feeding trials, and no provisions were made to measure carry-over effects between periods, the adjusted income above feed cost was calculated on a TDN basis (presented in

TABLE 5

Average flavor scores of different silages

Silage	No. of samples	Flavor score
	Experiment 2, 1955–56	
Dixie 18 corn	157	37.1
Sart sorghum	159	37.2
Tracy sorghum	170	36.1
	Experiment 3, 1956–57	
Dixie 18 corn	80	36.8
Tracy sorghum	78	35.8
Texas seeded-ribbon	78	36.9

Table 4). The TDN allowances used were those recommended by the National Research Council *(9)*—0.32 lb. TDN per lb. FCM; and Knott, *et al. (7)*—3.53 lb. TDN per lb. of gain in body weight, and 2.73 lb. TDN per lb. of loss in body weight.

Data on the flavor of milk produced are shown (Table 5). Tracy sorghum produced a stronger silage flavor in the milk than any of the other types of silage fed. Some of the samples of milk from cows fed Tracy sorghum would not have been acceptable on a Class I market.

SUMMARY

Corn, and one or more varieties of sorghum, were grown for silage in alternate strips in the same field in three tests. The yield of corn was considerably less than any variety of sorghum each year, especially during the dry summer of 1954. One double-reversal and two Latin-square design feeding trials were conducted with from 22 to 27 cows in each test, to compare silage from these crops. Cows produced more milk, consumed more silage, and gained more weight each year on the corn silage than on any variety of sorghum. These differences were highly significant ($P < 0.01$). Milk produced by cows receiving Tracy sorghum had a stronger silage flavor than that produced by any other type of silage fed.

REFERENCES

(1) Blount, C. L. Sorgo, Millet Crops Compared in Silage Study. *Mississippi Farm Research*, 17(2): 1. 1954.

(2) Crockett, S. P. Corn Compared with Sorghum in Silage Test. *Mississippi Farm Research*, 16(4): 4. 1953.

(3) Crockett, S. P. Corn and Sorghum Silage Compared in North Mississippi. *Mississippi Farm Research*, 17(3): 5. 1954.

(4) Cunningham, W. S., and Reed, J. R. Japanese Honeydrip Sorghum Silage versus June Corn Silage for Milk Production. Arizona Agr. Expt. Sta., *Bull.* 122. 1927.

(5) Downs, P. A., Anderson, E. O., Babcock, C. J., Herzer, F. H., and Trout, G. M. Committee on Judging Dairy Products, A.D.S.A. Evaluation of Collegiate Student Dairy Products Judging Since World War II. *J. Dairy Sci.*, 37: 1021. 1954.

(6) Good, E. S., Horlacher, L. J., and Grimes, J. C. A Comparison of Corn Silage and Sorghum Silage for Fattening Steers. Kentucky Agr. Expt. Sta., *Bull.* 233. 1921.

(7) Knott, J. C., Hodgson, R. E., and Ellington, E. V. Methods of Measuring Pasture Yields with Dairy Cattle. Washington Agr. Expt. Sta., *Bull.* 295. 1934.

(8) LaMaster, J. P., and Morrow, K. S. Corn Silage versus Sweet Sorghum Silage for Milk Production. South Carolina Agr. Expt. Sta., *Bull.* 254. 1929.

(9) Loosli, J. K., Huffman, C. F., Petersen, W. E., and Phillips, P. H. *Recommended Nutrient Allowances for Domestic Animals. III. Recommended Nutrient Allowances for Dairy Cattle.* National Research Council, Washington, D. C. 1950.

(10) Nevens, W. B., and Kendall, K. A. Sorghums and Soybeans as Silage Crops for Milk Production. Illinois Agr. Expt. Sta., *Bull.* 578. 1954.

(11) Ray, M. L., and Thurman, R. L. Tracy Silage Equals Atlas Sorgo Silage. Arkansas Agr. Expt. Sta., *Farm Research*, 5(2):8. 1956.

(12) Snedecor, G. W. *Statistical Methods.* Iowa State College Press, Ames. 1946.

(13) Stokes, I. E., Coleman, O. H., O'Kelly, J. F., Crockett, S. P., Kuykendall, R., Freeman, K. C., and Hurt, B. C. Tracy—A New Mid-Season Variety of Sorgo for Sirup Production in Mississippi. *Mississippi Farm Research*, 16(6): 1953.

(14) Stokes, I. E., Coleman, O. H., O'Kelly, J. F., Hurt, B. C., Kuykendall, R., and Crockett, S. P. Sart Developed in Six-Year Test of Hundreds of Seedlings at Four Locations. *Mississippi Farm Research*, 14(3): 1. 1951.

MEASUREMENT OF TESTICULAR SIZE AND ITS RELATION TO PRODUCTION OF SPERMATOZOA BY BULLS

E. L. WILLETT AND J. I. OHMS[1]

American Foundation for Biological Research, Madison, Wisconsin

The correlation between scrotal circumferences in situ and weight or volume of excised testes was .94. The correlation between scrotal circumferences and spermatozoan production was only .43 and .32 with bulls in routine service, but with four exhaustions at weekly intervals with each bull the correlation was .92 with 16 young bulls and − .53 with 6 aged bulls. It was estimated that nine young bulls the first year averaged 48.5 × 10^6 spermatozoa per gram of testicular tissue per week; seven of these bulls a year later, 63.4 × 10^6, and the aged bulls, 46.7 × 10^6. *Editor.*

To attain most rapid improvement of dairy cattle and efficient operation of bull studs, it is imperative that the maximum number of cows be bred to outstanding sires by artificial insemination. One line of study that may contribute to the attainment of this objective is the development of a method to measure quantitatively the spermatozoan-producing capacity of individual sires in regular service in bull studs.

The initial step toward measuring the full reproductive capacity of bulls was made by Kirillov and Morozov *(13)*. They compared production of spermatozoa by bulls ejaculated at different frequencies, and collected as many as 24 ejaculates from a bull in 27 hr. Shortly thereafter, Walton and Edwards *(22)* collected a number of ejaculates from bulls at intervals of a few minutes and termed the technique the exhaustion test. Edwards *(8)* adapted this technique to the estimation of number of spermatozoa produced per gram of testis per week. He counted the number of spermatozoa in eight ejaculates collected weekly for 4 wk. from eight rabbits, then weighed the excised testes at the end of the 4-wk. period. From these data, a correlation of .95 can be calculated. He estimated that each gram of testicular tissue produced approximately 100 × 10^6 spermatozoa per week. Ortavant *(19)* obtained semen from rams by daily electro-ejaculation and then counted the number of spermatozoa in the excised reproductive tracts. He demonstrated that there is a correlation of .80 between testicular size and number of spermatozoa therein. In addition, the correlation between number of spermatozoa in the testis and in the caput epididymis was .90. The number in the caput was not changed appreciably by collection of semen. Also, a correlation of .80 was found between number of spermatozoa in the testis and in the cauda epididymis. The cauda appeared to be the chief source of spermatozoa when rams were exhausted by electro-ejaculation. He gave a formula by which one could estimate the number of spermatozoa

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[1] Present address of authors: Department of Dairy, Michigan State University, East Lansing.

produced daily by the testes, taking into account changes in spermatic reserves in the reproductive tract. More recently, Almquist and Hale *(1)*, Boyd and VanDemark *(5)*, and VanDemark *(20)* have measured the rate of production of spermatozoa by bulls by means of exhaustion trials, and Boyd and VanDemark estimated that 2,880,000 spermatozoa were produced per gram of testicular-epididymal tissue per day. In most of these investigations, where estimates were made of the number of spermatozoa produced per unit weight of testis, or where a relationship between amount of testicular tissue and production of spermatozoa was demonstrated, males were killed to obtain the weights of testes.

This paper reports the results of studies concerning the estimation of size of testes in the living bull, the relation of testicular size to body size and to production of spermatozoa, estimation of spermatozoan production per gram of testis, and the average of, and variation in, size of testes of mature bulls. A portion of these data has already been reported in abstract form *(24, 25)*.

EXPERIMENT I

Measuring Testicular Size in Situ

The first step in the study of the relationship of testicular size to production of spermatozoa by bulls was to develop a method of measuring size of testes in situ.

Experimental procedure. Two measurements were made on slaughterhouse bulls with intact scrota while they were lying on their backs, about 15 min. after being killed: *(a)* circumference at a point on the scrotum equivalent to the place of maximum horizontal circumference when the bull is standing, and *(b)* length of each testis. Circumference was measured with a physician's steel tape, while an assistant held the scrotum gently, to force the testes into the end of the scrotum. The length of testis was measured with an obstetrical pelvimeter. The testes were then removed. In both of the series made in this study, the volumes of the testes, together with the epididymides, were measured by water displacement. In the second series, volumes and weights of excised testes without the epididymides were also measured. The origins of the bulls were unknown and they varied greatly in size and age, although a large majority was mature.

Results and discussion. Correlation coefficients obtained in these two series are presented (Table 1).

In Series I, the average circumference of the scrotum was 30.2 cm. and ranged from 19.7 to 37.2 cm. The volume of individual pairs of testes with epididymides averaged 595.4 ml. and ranged from 213 to 975 ml. The measurement of length of each testis contributed nothing to the information obtained by measuring only the circumference of the scrotum. The correlation between scrotal circumference and testicular volume with epididymides was .94.

In Series II, the average weight of pairs of testes was 541 g., volume, 513 ml., and scrotal circumference, 34.9 cm. The correlation between scrotal circumference and volume of testes with epididymides was .94, without epididymides, .96, and weight of testes without epididymides, .95. As one might expect,

TABLE 1

Correlations between various measurements of size of testes, and regression of weight or volume on scrotal circumference.[a]

Variables	Bulls	Correlation coefficient	Regression coefficient
Series I	*(No.)*		
Length and volume with epididymides	53	.63	
Scrotal circumference and volume with epididymides	53	.94	38.21
Volume with epididymides *vs.* product of scrotal circumference and average testicular length in situ	53	.91	
Series II			
Scrotal circumference and volume with epididymides	16	.94	38.12
Scrotal circumference and volume w/o epididymides	16	.96	36.44
Scrotal circumference and weight w/o epididymides	16	.95	37.73
Testicular weight w/o epididymides and testicular volume w/o epididymides	16	.997	

[a] Data from bulls at slaughterhouse.

testicular weight and volume, both without epididymides, were highly correlated, with the coefficient being .997. The sample standard deviation from regression of weight of testes without epididymides on scrotal circumference was 42.4 g. These data indicate that size of testes of bulls can be estimated quite accurately in situ by measurement of scrotal circumference. Boyd and VanDemark *(5)* obtained a correlation of .94 between testis-epididymis weight and measurement of length times width.

EXPERIMENT II

Relation of Size of Testes to Production of Spermatozoa by Stud Bulls

With a method at hand of estimating size of testes in situ, a study was made of the relationship of size of testes to production of spermatozoa. For this work, data on spermatozoan production by bulls in routine service were readily available.

Experimental procedure. Scrotal circumferences of bulls in three studs were measured twice by one man. In Series I, total spermatozoan production for one year was computed from routine records for each bull which had been in service a full year. In Series II, total spermatozoan production for a 5-mo. period was computed. In this series, only those bulls from which semen had been collected regularly during this period were included. In both series, the number of ejaculates collected from each bull during the corresponding period was counted. Concentration of spermatozoa in each ejaculate was estimated by measurement of light transmission *(23)*.

Results and discussion. In Series I, the correlation between scrotal circumference and total number of spermatozoa from 47 bulls was .46 ($P < .01$). When numbers of ejaculates were held constant by partial correlation, the coefficient was .43.

In Series II, the correlation between scrotal circumference and total number of spermatozoa for 12 beef bulls was .46, and for 60 dairy bulls, .17. The difference between these two coefficients is not significant. The correlation for all 72 bulls combined was .32 ($P < .01$). When numbers of ejaculates during the period were held constant by partial correlation, the correlation was .44 for the beef bulls, .16 for dairy bulls, and .30 for all bulls.

The significant correlations indicate that there is a definite relationship between size of testes, as measured by scrotal circumference, and spermatozoan production. With a correlation of .30, however, only 9% ($.30^2$) of the variation in spermatozoan production is accounted for by measurement of scrotal circumference.

EXPERIMENT III

Relation of Size of Testes to Production of Spermatozoa Measured by the Exhaustion Test

Since the relationship of testicular size to production of spermatozoa under field conditions had given correlations too low to indicate that estimation of one by the other was possible, an additional study was carried out using a more precise technique, the exhaustion test.

Experimental procedure. Before beginning an exhaustion series, two ejaculates had been collected regularly once weekly from each bull. An exhaustion series with an individual bull consisted of four exhaustions at weekly intervals for 4 wk. In each exhaustion, ejaculates were collected at 10-min. intervals until two successive ejaculates, accompanied by vigorous thrusts and with a total of less than 500×10^6 spermatozoa per ejaculate, were obtained. Scrotal circumference of each bull was measured four times in most cases and, in a few instances, three times. Number of spermatozoa in each ejaculate was estimated by measurement of light transmission *(23)*.

The weight of testes for each bull was estimated by means of the regression formula for testicular weight without epididymides on scrotal circumference. The formula was derived from measurements on 16 slaughterhouse bulls in the first study in this paper (see Table 1). The regression formula is

$$\hat{Y} = 37.73X - 776.18$$

where $\hat{Y}$ is testicular weight in grams and X is scrotal circumference in centimeters. The average of the last three exhaustions was taken as the production of spermatozoa per week for each bull.

At the beginning of this study, the mounts (females or other bulls) were changed after each five ejaculates but, shortly thereafter, changes were made after each three ejaculates.

In this study there were nine young and six aged bulls. These aged bulls had been removed from service in studs, for reasons other than reduced fertility or libido.

Results and discussion. Seven young bulls each experienced two exhaustion series at intervals of approximately one year, and two young bulls and the six

aged bulls each were in only one exhaustion series. Ejaculates per exhaustion with the young bulls, during the first series, ranged from six to 19 and averaged 11.0; during the second series, they ranged from 11 to 19 and averaged 14.4. With the aged bulls, ejaculates per exhaustion ranged from 11 to 22 and averaged 16.0. The average number of spermatozoa in successive exhaustions with the young bulls, first series, was 19.4, 21.3, 19.2, and 20.3×10^9; with the young bulls, second series, 39.8, 36.0, 29.9, and 32.7×10^9, and with the aged bulls, 42.4, 36.5, 33.6, and 30.8×10^9. The average number of spermatozoa in the first exhaustions was significantly greater than in the subsequent exhaustions with young bulls, second series; and with the aged bulls, but not with the young bulls, first series.

Information and results for each bull are presented (Table 2). The average number of spermatozoa produced per week for the young bulls, first series, was 20.3×10^9, second series, 32.9×10^9; and for the aged bulls, 33.6×10^9.

On the basis of estimated testicular weights without epididymides, and the average number of spermatozoa from the last three exhaustions for each bull, estimates were made of the number of spermatozoa produced by each bull per gram of testicular tissue per week. As can be seen (Table 2), the young bulls averaged 48.5×10^6 spermatozoa per gram of tissue per week during the first series, and 63.4×10^6 during the second series. The aged bulls averaged 46.7×10^6. The mean for the young bulls, second series, is highly significantly greater ($P < 0.01$) than the two other means. The difference between the young bulls, first series, and the aged bulls, is not significant.

TABLE 2

Age and breed of bulls, scrotal circumference, average spermatozoan production per week, and estimated number of spermatozoa produced per week per gram of testis

Bull	Age, 1st series	Scrotal circumference		Av. sperm/wk ($\times 10^9$)		Sperm/g wk. ($\times 10^6$)	
		1st series	2nd series	1st series	2nd series	1st series	2nd series
				Young bulls			
1 (H)[a]	18 mo.	30.2	35.6	17.0	35.9	46.8	63.2
4 (H)	3 yr.	30.5	32.4	16.7	25.8	44.6	57.7
5 (H)	18 mo.	30.9		21.6		55.5	
26 (G)	12 mo.	33.6	37.0	19.8	39.0	40.3	62.9
27 (G)	12 mo.	29.5	32.7	11.2	25.5	33.1	55.8
28 (B)	12 mo.	34.7	35.4	34.2	42.1	64.2	75.3
29 (B)	11 mo.	30.9	32.4	20.2	29.8	51.9	66.7
30 (G)	11 mo.	31.7	34.2	20.8	32.0	49.6	62.3
31 (G)	13 mo.	31.7		21.1		50.2	
Av.	16 mo.	31.5	34.2	20.3	32.9	48.5	63.4
				Aged bulls			
B (J)	9 yr.	40.5		30.7		40.9	
C (B)	9 yr.	40.7		34.6		45.6	
Je (G)	9 yr.	38.9		44.7		64.7	
Ju (H)	10 yr.	38.8		32.1		46.6	
L (G)	9 yr.	40.4		26.4		55.3	
S (G)	9 yr.	39.4		33.3		46.9	
Av.	9 yr.	39.8		33.6		46.7	

[a] Letters in parentheses indicate breed: B, Brown Swiss; G, Guernsey; H, Holstein, and J, Jersey.

With the 16 exhaustion series with young bulls, the correlation between scrotal circumference and average number of spermatozoa in the last three exhaustions was .92; in all four exhaustions, .91; in the first three exhaustions, .88; in the first two exhaustions, .84, and in the first exhaustion only, .80. For the six aged bulls, the correlation between scrotal circumference and average number of spermatozoa in the last three exhaustions (production per week) was $-.53$ ($P > .05$). The correlations indicate that, at least with young bulls with the range of testicular sizes in this study, the capacity to produce spermatozoa can be predicted with fair accuracy by testicular size, as estimated by scrotal circumference. Thus, by measuring circumference, one is able to account for 85% (0.92^2) of the variation in capacity to produce spermatozoa, as measured by the exhaustion procedures employed in this study. The regression equation is

$$\hat{Y} = 3.73X - 96.18$$

where $\hat{Y}$ is the number of spermatozoa in millions produced per week and X is the scrotal circumference in centimeters. The sample standard deviation from regression is 3.60×10^6 spermatozoa.

With aged bulls, however, the data give little promise of estimating production of spermatozoa by measuring scrotal size. These relationships are shown

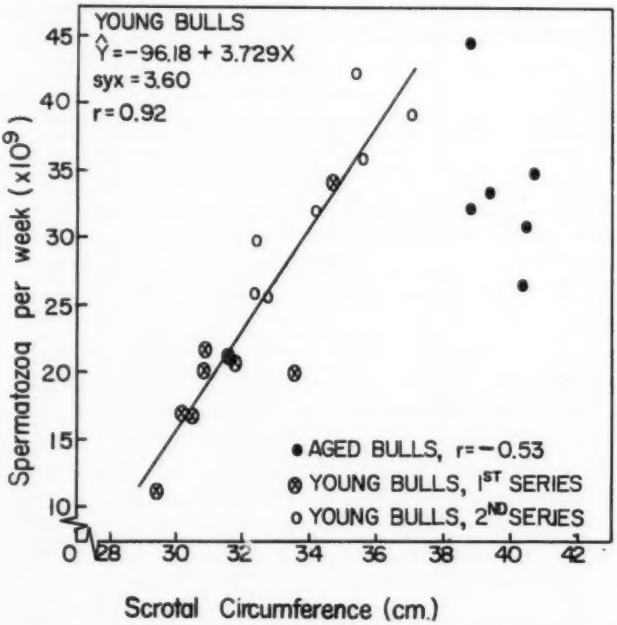

FIG. 1. Relation of production of spermatozoa to scrotal circumference. Regression line is for number of spermatozoa per week on scrotal circumference, young bulls.

(Figure 1), where number of spermatozoa produced per week is plotted against scrotal circumference. The data for the young bulls follow the regression line closely, but the data for the aged bulls are scattered.

These data suggest that the bull's testis after puberty continues to increase in its capacity to produce spermatozoa per unit volume and that, with the approach of senescence, the testis diminishes in this capacity. These trends are only partially supported by histological studies of testes in mammals, throughout a portion, or all, of their life following puberty. In reference to postpubertal development, Nishikawa and Horie *(17)* and Onuma and Nishikawa *(18)* measured diameter of seminiferous tubules and degree of spermatogenic activity in testes from goats, stallions, mice, and bulls. Their evidence indicated that the testis attains full spermatogenic activity a short time after puberty and thereafter increases only in size until full growth is attained. Knudsen *(14)* found a largely uniform testicular picture in bulls 8 mo. to 7 yr. of age. It is also of interest to note that Hooker *(10)* observed an increase in androgen content of bull testes to 5 yr. of age. In the present study, the increase in number of spermatozoa produced per gram of testis from the first to the second series does not, then, agree with the literature concerning postpubertal bulls.

In reference to the period after full sexual development is attained in the bull at 5 to 7 yr. of age, a mass of evidence from various sources has shown that the testes of a large percentage of bulls undergo varying degrees of degeneration *(4, 11, 14, 15)*. In addition, Hooker *(10)* observed a gradual decrease in androgen content of bull testes after 5 yr. of age. The diminished productive efficiency of the aged bulls' in the present study does, then, agree with the published evidence. To establish definitely the true course of events in the rise and decline of productive efficiency of the testes of the bull, detailed quantitative studies of spermatogenesis, of the nature of those by Clermont and Morgentaler *(7)*, Jones and Lamoreux *(12)*, and Nelson *(16)*, and additional studies of the capacity to produce spermatozoa, are needed.

The low correlation between scrotal circumference and spermatozoan production computed from data collected during routine stud operations, and the contrastingly high correlation calculated from exhaustion trials, support the conclusions of Edwards *(8)* and Venge and Frölich *(21)* that (quoting Edwards) "An exhaustion test is superior to isolated collections, where reserves and rates of production of spermatozoa are to be measured." The difference between these two methods of measuring spermatozoan production, as reported in the present paper, may also be explained in part by the fact that the high correlations with the exhaustions were obtained with young bulls; whereas, the measurements in the studs were made on mature bulls, many of which were aged.

Among the young bulls in this study there were three pairs of twins: No. 26 and 27, 28 and 29, and 30 and 31. The numbers of spermatozoa produced per gram of testicular tissue per week were quite similar within pairs in both the first and second series (Table 2). However, from these data, the heritability of

this trait can not be reliably determined, because of the small number of bulls and the experimental design. It is of interest to note, however, that in a careful study with rabbits, Venge and Frölich *(21)* concluded that semen volume is genetically determined only through body weight, but that concentration of spermatozoa, although influenced greatly by environmental factors, is directly influenced by genes.

EXPERIMENT IV

Relation of Testicular Size to Body Size

Because it would be easier, at least with some bulls, to measure body size rather than scrotal size, it would be advantageous if the size of the latter could be estimated from the former. Studies were, therefore, carried out on mature bulls, to determine the correlation between these two measurements. The study of this problem included three series of measurements on mature bulls.

Series I consisted of weights of pairs of testes without epididymides from slaughterhouse bulls (just described). Weights of carcasses of 13 of these were also obtained. The correlation was .53 ($P = .05$).

Series II included scrotal circumferences and heart girths of bulls in one bull stud. At least two of each measurement were made on each bull and averaged. The correlation for 54 dairy bulls was .31 ($P < .05$) and for nine beef bulls, .47 ($P > .05$).

In Series III, dairy bulls in one stud were weighed once and again one week later, and scrotal circumferences were measured twice. The correlation for the 26 bulls was $-.03$. As determined by analysis of variance, there was a highly significant difference ($P < .001$) in body weights among dairy breeds, but the breed differences in scrotal circumferences were not significant, whether or not the means were adjusted to the same body weight by covariance. The covariance analysis also indicated that the same regression line could be employed for these three breeds (Brown Swiss, Guernsey, and Holstein).

The correlations in these three series indicate that measurement of body size does not permit reasonable accuracy in estimation of testicular size in mature bulls. Similarly, from data reported by Bane *(3)* for bulls, a correlation of only .34 between body weight and testicular weight can be calculated. On the other hand, when gathering data throughout the course of body growth, an apparently close relationship can be observed between body weight and testicular size, because of the great ranges in these variables *(2, 11, 20)*. However, the relationships obtained in those instances do not necessarily mean that prediction is possible with mature animals within one species, where the range in testicular size is comparatively small in proportion to the standard deviation from regression. Additional support for this statement is given in work wherein the relationships, although in some instances significant, between body weight and production of spermatozoa *(9, 21)*, or between body weight and semen volume in the bull *(6)*, are too low to indicate reasonable accuracy in prediction

of one variable by the other for individual males. However, it should be mentioned that in some of these investigations measurement of spermatozoa produced was not accomplished by some form of an exhaustion test.

EXPERIMENT V

Testicular Size in a Population of Bulls

In order to have an estimate of the population means and ranges of scrotal circumferences of fully mature bulls by breeds, measurements of bulls were made in six different artificial-breeding organizations.

Measurements were made by several men. However, most were by two individuals who had worked together. In five of these organizations, two measurements were made on each bull; whereas, in the remaining organization an average of 4.8 measurements was made, in some instances over a period of two years. Averages, standard deviations, ranges, and 5% confidence limits were calculated for each breed.

A summary of the data from this population study is presented (Table 3). Each confidence limit is an estimate of the range within which 95% of the scrotal

TABLE 3

Averages and confidence limits for scrotal circumferences af mature bulls by breeds (A population study)

Breed	Bulls	Scrotal circumference *(cm.)*		
		Av.	Range	5% confidence limit
	(No.)			
Angus	28	38.3	34.8–44.2	33.8–42.8
Brown Swiss	31	41.0	36.0–46.6	35.2–46.8
Guernsey	101	41.0	31.8–46.4	35.6–46.4
Hereford	12	37.9	33.8–41.6	33.0–42.8
Holstein	135	41.0	33.6–47.8	35.3–46.7
Jersey	41	38.5	32.2–43.1	32.7–44.3
Shorthorn	13	40.3	36.0–45.6	34.7–45.9

circumferences of individual bulls within each breed falls. The figures in this table give an indication of the normal variation in circumference of testes of bulls, and can be useful in determining whether or not the scrota of individual bulls are close to the population mean or are approaching extremes in size.

Analysis of variance indicated that there are no statistically significant differences between the mean scrotal circumferences of Brown Swiss, Guernsey, Holstein, and Shorthorn bulls, or between means for Angus, Hereford, and Jersey bulls. However, the means for the latter three breeds are significantly different ($P < .01$) from each of the means for the others.

The mean square for between the first two measurements within bulls was calculated. From this mean square for measurements made only by Foundation personnel, an experimental error of .84 cm. was computed.

SUMMARY AND CONCLUSIONS

Studies have been made of various phases of the relationship between testicular size and spermatozoan production by bulls.

By measuring scrotal circumferences in situ, and volumes or weights of excised testes of 69 bulls in a slaughterhouse after the animals were killed, a correlation of .94 was obtained. Measuring testicular length in situ did not increase accuracy.

Low correlations of .43 and .32 were found between scrotal circumferences and numbers of spermatozoa produced by bulls in routine service in bull studs, during periods of 1 yr. and 5 mo., respectively.

Exhaustions were carried out with experimental bulls, to study the relationship between scrotal circumference and production of spermatozoa. An exhaustion series with each bull consisted of four exhaustions at weekly intervals. With 16 young bulls, there was a correlation of .92, and with six aged bulls, $-.53$ ($P > .05$). Nine young bulls averaged 20.3×10^9 spermatozoa per week the first year; seven of these bulls, 32.9×10^9 a year later, and the six aged bulls, 33.6×10^9. It was estimated that the young bulls the first year averaged 48.5×10^6 spermatozoa per gram of testicular tissue per week, and for the second year, 63.4×10^6. The aged bulls averaged 46.7×10^6.

It was found, in three studies on the relationship of testicular size to body size of mature bulls, that the correlation was too low to permit estimation of one by the other.

Averages, ranges, and 5% confidence limits by breeds are given for scrotal circumferences of 361 bulls, representing seven breeds in six artificial-breeding organizations.

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REFERENCES

(1) Almquist, J. O., and Hale, E. B. An Approach to the Measurement of Sexual Behavior and Semen Production of Dairy Bulls. *Proc. IIIrd Intern. Congr. Animal Reproduction*, Plenary Papers. p. 50. 1956.

(2) Baker, F. N., VanDemark, N. L., and Salisbury, G. W. The Effect of Frequency of Ejaculation on the Semen Production, Seminal Characteristics, and Libido of Bulls During the First Postpuberal Year. *J. Dairy Sci.*, **38**: 1000. 1955.

(3) Bane, A. Sexual Functions of Bulls in Relation to Heredity, Rearing Intensity and Somatic Conditions. *Acta Agr. Scand.*, **4**: 95. 1954.

(4) Barker, C. A. V. Some Observations on Testicular Calcification in Bulls. *Can. J. Comp. Med.*, **20**: 37. 1956.

(5) Boyd, L. J., and VanDemark, N. L. Spermatogenic Capacity of the Male Bovine. I. A Measurement Technique. *J. Dairy Sci.*, **40**: 689. 1957.

(6) BRANTON, C., AND SALISBURY, G. W. The Estimation of the Weight of Bulls from Heart Girth Measurements. *J. Dairy Sci.*, **29**: 141. 1946.

(7) CLERMONT, Y., AND MORGENTALER, H. Quantitative Study of Spermatogenesis in the Hypophysectomized Rat. *Endocrinology*, **57**: 369. 1955.

(8) EDWARDS, J. The Effect of Unilateral Castration on Spermatogenesis. *Proc. Roy. Soc. (London) B.*, **128**: 407. 1940.

(9) FRÖLICH, A., AND VENGE, O. Semen Production in Different Breeds of Rabbit. *Acta Agr. Suecana*, **3**: 83. 1948.

(10) HOOKER, C. W. Testis Hormone in Relation to Age. *Endocrinology*, **21**: 655. 1937.

(11) HOOKER, C. W. The Postnatal History and Function of the Interstitial Cells of the Testis of the Bull. *Am. J. Anat.*, **74**: 1. 1944.

(12) JONES, D. G., AND LAMOREUX, W. F. Semen Production of White Leghorn Males from Strains Selected for High and Low Fecundity. *Poultry Sci.*, **21**: 173. 1942.
lated title.) *Uspekhi Zootch. Nauk*, **4**: 140. 1937. *Animal Breeding* Abstr. **7**: 120. 1939.

(13) KIRILLOV, V. S., AND MOROZOV, V. A. Standards of Utilization of Stud Bulls. (Translated title.) *Uspekhi Zooteh. Nauk*, **4**: 140. 1937. *Animal Breeding Abstr.*, **7**: 120. 1939.

(14) KNUDSEN, O. Cytomorphological Investigations into the Spermiocytogenesis of Bulls with Normal Fertility and Bulls with Acquired Disturbances in Spermiogenesis. *Acta Pathol. Microbiol. Scand., Suupl.* 101. 1954.

(15) LANCASTER, M. C. A Survey of Pathological Changes in the Testicles of A. I. Bulls. *Proc. IIIrd Intern. Congr. Animal Reproduction*, II. p. 71. 1956.

(16) NELSON, W. O. Evaluation of Testicular Function. *Reproduction and Infertility*, p. 79. Centennial Symposium, Mich. State Univ., 1955.

(17) NISHIKAWA, Y., AND HORIE, T. Studies on the Development of the Testes and Epididymides of the Horse. I. Studies on the Development of the Testes of the Horse, with Special Reference to Singularity and the Age of Sexual Maturity. *Bull. Natl. Inst. Agr. Sci. (Japan) G*, No. 10, p. 299. 1955.

(18) ONUMA, H., AND NISHIKAWA, Y. Some Observations on the Development of a Goat's and a Mouse's Testes with Special Reference to Those of a Horse. *Bull. Natl. Inst. Agr. Sci. (Japan) G*, No. 10, p. 365. 1955.

(19) ORTAVANT, R. Recherches quantitatives sur la Spermatogénése et les réserves Spermatiques du Bélier. *Proc. IInd Intern. Congr. Physiol. and Pathol. Animal Reproduction and Artificial Insemination*, I. p. 63. 1952.

(20) VANDEMARK, N. L. Quantitative Aspects of Semen Production in Bulls. *Proc. IIIrd Intern. Congr. on Animal Reproduction*, Plenary Papers. p. 80. 1956.

(21) VENGE, O., AND FRÖLICH, A. Semen Production in Different Breeds of Rabbit. II. *Acta Agr. Scand.*, **1**: 291. 1951.

(22) WALTON, A, AND EDWARDS, J. Criteria of Fertility in the Bull. I. The Exhaustion Test. *Proc. Am. Soc. Animal Production*, p. 254. 1938.

(23) WILLETT, E. L., AND BUCKNER, P. J. The Determination of Number of Spermatozoa in Bull Semen by Measurement of Light Transmission. *J. Animal Sci.*, **10**: 219. 1951.

(24) WILLETT, E. L., AND OHMS, J. I. Testicular Size and Production of Spermatozoa by Bulls. *J. Animal Sci.*, **14**: 1261. 1955.

(25) WILLETT, E. L., AND OHMS, J. I. Relation of Testicular Size to Production of Spermatozoa by Young and Aged Bulls. *J. Dairy Sci.*, **40**: 622. 1957.

EFFECTS OF TWO-STAGE STERILIZATION ON THE PHYSICO-CHEMICAL PROPERTIES OF EVAPORATED MILK[1, 2]

D. B. GAMMACK[3] AND K. G. WECKEL
Department of Dairy and Food Industries, University of Wisconsin, Madison

Sterilized evaporated milks processed with the usual cycles at 240, 250, and 260° F. were compared with those in which an intermediate hold period of from 5 to 10 minutes at 220 and 200 was employed during the come-up and come-down cycles. The use of the intermediate hold during the come-up stage increased viscosity and reduced fat and protein separation at 100° F. storage; less effective results were obtained with the interrupted come-down treatment. Color of the milk processed with the interrupted come-up was preferable to that given the interrupted come-down treatment. *Editor.*

Conventional methods of sterilizing evaporated milk use time-temperature combinations of 240 to 243° F., with from 15 to 18 min. of holding time, or higher temperatures such as 250° F. with from 5 to 7 min. of holding time. A more recent innovation has been the use of so-called high-short (high-temperature–short-time) sterilization treatment, in which milk in cans is heated with marked agitation at about 260° F. for from 1 to 4 min. or, alternatively, heated by direct steam injection, or in a tubular heater, at about 285° F. for from 10 to 15 sec. and then filled into cans aseptically. The latter method is described by Curran *et al. (5)*.

Milk sterilized by high-short methods tends to have a thin body, which allows rapid separation of fat and protein, severely limiting the storage life of the product. Webb *et al. (21)* noted that protein was adsorbed on the fat phase, which rose as a layer, gel-like in structure and not readily dispersible. Maxcy and Sommer *(10)* were able to show that a good correlation existed between gravity-fat separation and the combined effectiveness of homogenization and viscosity. These authors, in later papers *(11, 12)*, developed mathematical relationships for age-thinning as affected by time of sterilization and the time and temperature of storage. They observed a greater retardation of fat separation by increased time of sterilization than would be expected solely from the resulting increase in viscosity. Milk sterilized by high-short methods has a quality of color and flavor superior to milk sterilized by conventional low-temperature methods, as reported by a number of workers *(2, 13, 18)*.

Bell *et al. (2)* observed that high-short sterilized milk had a tendency to thicken on prolonged storage. They were able to reduce this gelation tendency, however, by further heating of the milk in cans at 239° F. after high-short

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[2] These data are part of a thesis submitted by the senior author for the degree of Master of Science in Dairy Industry.

[3] Present address: Dairy Department, University of Reading, England.

sterilization, which increased the color of the milk. Nelson *(15)* decreased fat separation without increased color with a steam-jet, in forewarming to 210° F. and preheating at 227° F. for 9 min. He observed no gelation or increase in viscosity after 90 days of storage at 100° F. Simonson and Tarassuk *(16)* noted that fat separation and gelation were directly associated with sterilization temperature and temperature of storage, and suggested that a temporary solution to the problem of these defects would be the low-temperature storage of high-short sterilized milk. They observed little or no fat separation or gelation at a storage temperature of 40° F. Tarassuk and Tamsma *(19)* were able to retard gelation by certain preheating treatments of the milk in a concentrated state.

The trend in application of heat-process treatments for evaporated milk since its first inception has been consistently in the direction of higher temperatures for shorter periods of time. This has been due in part to mechanical output factors and, in part, to an effort to improve the product. The possible effects of multiple-stage heat treatment of the milk within the normal temperature ranges appear not to have been studied. The present study was undertaken to examine the effects on some of the physico-chemical properties of evaporated milk of various two-stage sterilization procedures, in which an intermediate holding period was introduced during the come-up or come-down stage of sterilization. As a result of the preliminary studies of Federer *(7)* and Dean *(6)*, application of heat at a temperature below that known to have serious effects on the color and flavor of the milk, showed promise as a means of conditioning the milk to a high sterilization temperature and of improving its storage stability by bringing about a significant increase in viscosity.

Subsequent to the initiation of this study in 1953, a patent was issued in 1955 *(8)*, describing a method claimed to impart satisfactory storage stability to evaporated milk without affecting its color and flavor. A holding period of 10 min. at 235° F. was applied after sterilization of the milk at 260° F.

EXPERIMENTAL PROCEDURE

Milk which had been standardized to legal composition for evaporated milk, viz., to 7.9% fat and 25.9% total solids, was obtained in bulk quantity from a nearby Wisconsin plant. The milk had been forewarmed to from 208 to 210° F. and homogenized at 2,000 p.s.i. Chemical stabilizer had been added to some lots, depending on the heat stability of the milk, as determined by pilot tests in the plant. Further additions were not made in these experiments. The milk was tempered to 80° F. before filling into special heavy-plate, 211 by 413 plain tin cans, chosen to withstand high internal pressure, as required for certain non-milk food products.

The pilot sterilizer used was a single-unit cylindrical Berlin-type retort equipped with a special-design, eight-pocket reel. The reel was rotated continuously throughout the sterilization process at 12 r.p.m. The temperature in the retort was controlled by a Honeywell cam-operated controller-recorder, which permitted excellent reproduction of all variables in the temperature treatments.

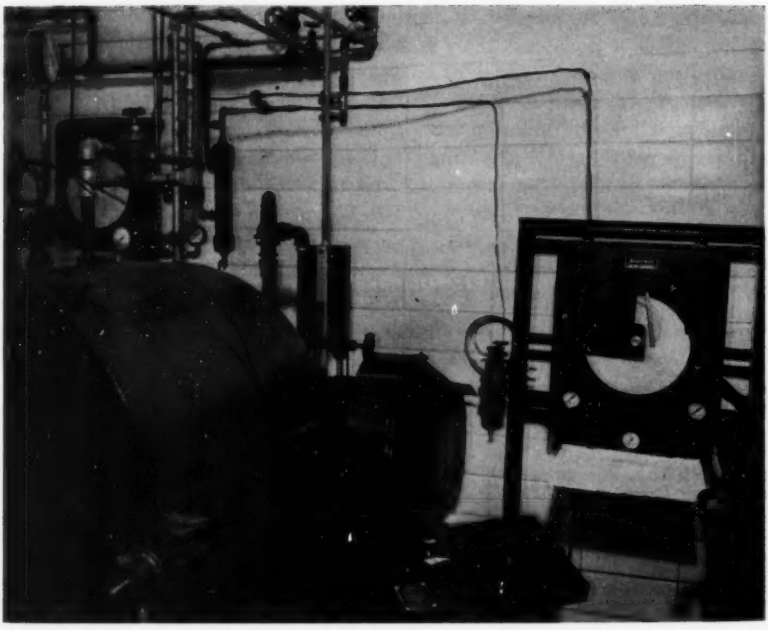

FIG. 1. View of retort showing potentiometer connections and cam-operated temperature controller.

A thermocouple inserted into one of the several cans on the reel enabled temperature measurements to be made during sterilization, for evaluation of the sterilization processes. The cans were cooled rapidly by water sprays directed onto the revolving reel. Illustrations of the equipment are shown (Figures 1 and 2).

A series of preliminary tests were made to determine suitable time and temperature combinations for interrupted two-stage sterilization processes. The time and temperature combinations shown (Table 1) were selected for detailed study. When an intermediate holding period was included in the come-up stage, making the procedure a two-stage process, the rate of rise from the intermediate holding temperature to the final sterilization temperature was the same as in

TABLE 1

Time-temperature combinations for processes employed in study[a]

Process series	Single-stage process (control)				Two-stage holding process	
	Come-up time	Sterilization temperature	Sterilization time	Cooling time	Intermediate temperature	Holding time
	(min.)	*(°F.)*	*(min.)*	*(min.)*	*(°F.)*	*(min.)*
A	18	240	15	4	220	10
B	19	250	7	4½	200	10
C	21½	260	1	5	200	5

[a] Times and temperatures quoted are those recorded in the retort chamber.

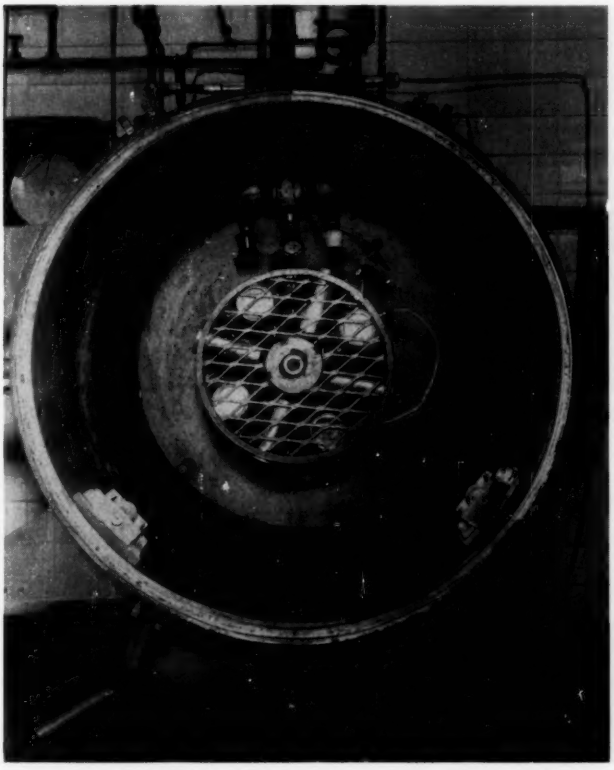

FIG. 2. View of inside of retort showing water sprays, 8-pocket reel with thermocouple connections to one can and to retort chamber.

the comparable single-stage control process. Similarly, the rate of cooling to the intermediate holding temperature was adjusted to be the same as in the control process.

Two of the eight cans obtained in each test-run were examined immediately after sterilization and the remainder were stored at 70 and 100° F. without inversion during the storage period, so that separation was allowed to proceed undisturbed. The physico-chemical properties of the milk were examined at intervals up to 4 mo. Viscosity measurements were made with a Brookfield viscosimeter with a range of 0 to 100,000 centipoises, the samples being tempered to 85° F. before measurement. The solid material (mainly fat and protein) which separated out as a result of age-thinning, and which remained immiscible with the other portion of the milk, was estimated by a gravimetric method. The contents of the can were poured slowly through a U. S. Standard No. 40 wire filter (opening size 0.0165 in. or 0.42 mm.) and the inverted can was allowed to drain for 30 sec. The amount of separated material was expressed as per cent

immiscible material. This was determined from the weight of milk solids retained by the filter and adhering to the inside of the can, i.e., the weight of the can and lid after drainage, minus the weight of the empty can and lid, calculated as a percentage of the total weight of milk in the can. Viscosity measurements were made on the solids-depleted milk after the solids separation test had been carried out. Color measurements were made with a Hunter color and color-difference meter *(9)*. This instrument gives three color values for each measurement, viz., the L-valve (visual lightness), the a_L-value (redness-greenness), and the b_L-value (yellowness-blueness). The browning reaction which occurs when milk is heated causes a decrease in the L-value and an increase in both the a_L- and b_L-values. Because of the smallness of the a_L-values they were not included in the analysis and interpretation of the data. A visual inspection of the inside of the cans was made to detect any burn-on or smear-on deposits. Grain formation in the milk was observed by the presence of coagulated material in a film formed by means of a wire loop. The processes used were such that no samples received heat treatment sufficient to cause graininess in the milk.

RESULTS AND DISCUSSION

The single-stage processes of 240° F/15 min. and 250° F/7 min. were selected as being representative of commercial procedures. Sterilization for 1 min. at 260° F. in the experimental equipment was found to produce a level of viscosity in the milk comparable to that given by other heat treatments, due to the comparatively long come-up time of 21½ min. Previous workers *(8, 15, 16, 18, 19)* have employed longer holding times at 260° F., but shorter come-up times.

The two-stage processes indicated (Table 1) were selected after a number of trial runs which indicated the amount of heat which could be applied without inducing graininess in the milk. The two-stage processes had sterilizing values equivalent to those of the single-stage process, as determined from heat penetration data plotted according to the method of Bigelow *et al. (3)* for each series, whether the intermediate holding period occurred during the come-up or come-down stage of sterilization.

Physico-chemical measurements were made of the milks sterilized in each comparison of the two-stage processes with the single-stage control process. A summary and analysis of the results obtained are given (Tables 2 through 7). The gravimetric method for estimating the amount of separated material in cans examined after storage was used in preference to previously described methods *(10, 17)*, because of the comparatively large amount of separation which prevented accurate withdrawal of samples for fat testing. Moreover, much of the material which separated out was of a nonfatty nature, having been swept up with the rising fat. The gravimetric method was rapidly performed and proved to be fairly sensitive. The effectiveness of the method could be judged by the good duplicate agreement for samples treated alike, and the almost complete absence of floating fat on samples stored at room temperature for from 4 to 5 days, after the immiscible material had been removed in performance of the test.

TABLE 2

Effect of sterilizing evaporated milk on its viscosity and storage stability[a]
(At 240° F. using come-up and come-down holding periods)

Series A sterilization treatment	Viscosity			Immiscible material separation	
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
	(cp.)			*(%)*	
240° F/15 min.	22.3	12.3	10.6	3.8	6.8
220° F/10 min.[b] 240° F/15 min.	63.4	29.2	18.8	2.9	4.3
240° F/15 min.[c] 220° F/10 min.	22.5	18.6	12.0	3.6	5.9
L.S.D.[d] P = 0.05	6.04	7.77	2.35	0.47	0.39
F-value	135.4 **	10.57**	30.56**	8.72**	21.99**

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
** Difference significant at the 0.01 level.

The two-stage heating methods brought about a reduction in the amount of material which separated out after samples had been stored at 70 and 100° F., when compared with milk processed by the usual single-stage methods (Tables 2, 4, and 6). The inclusion of a come-up holding period produced a significantly greater viscosity than the corresponding single-stage control process in all samples in Series A and B (Tables 2 and 4, respectively). The difference was not significant in samples sterilized at 260° F. and stored for 4 mo. at 70° F. (Table 6). A significant reduction in the amount of immiscible material which sepa-

TABLE 3

Effect of sterilizing evaporated milk on its color immediately after sterilization and after storage[a]
(At 240° F. using come-up and come-down holding periods)

Series A sterilization treatment	Hunter meter L-value			Hunter meter b_L-value		
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 2 mo. at 70° F.	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
240° F/15 min.	80.7	79.4	80.2	15.1	19.7	18.9
220° F/10 min.[b] 240° F/15 min.	79.3	77.7	79.5	16.9	21.0	19.7
240° F/15 min.[c] 220° F/10 min.	78.6	77.8	78.9	17.0	20.9	19.8
L.S.D.[d] P = 0.05	0.34	1.79	0.59	0.14	.....	0.05
F-value	83.79**	19.89**	51.12**	120.88**	.....	68.77**

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
** Difference significant at the 0.01 level.

TABLE 4

Effect of sterilizing evaporated milk on its viscosity and storage stability[a]
(At 250° F. using come-up and come-down holding periods)

Series B sterilization treatment	Viscosity			Immiscible material separation	
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
	(cp.)			*(%)*	
250° F/7 min.	34.3	15.8	10.7	4.2	5.4
200° F/10 min.[b] 250° F/7 min.	113.8	23.8	16.0	3.8	3.6
250° F/7 min.[c] 200° F/10 min.	26.2	15.5	11.5	4.5	5.2
L.S.D.[d] P = 0.05	28.15	2.73	1.74	0.68	1.05
F-value	5.17*	26.21**	23.51**	2.43[N.S.]	7.95**

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
* Difference significant at the 0.05 level.
** Difference significant at the 0.01 level.
[N.S.] Difference not significant.

rated out was observed in all samples processed in Series A, and in all samples processed in Series B and stored at 70° F. Least gain in viscosity was observed in the use of a come-up holding period in the 260° F. process (Table 6). This may have been due to the fact that the intermediate holding period had to be restricted to 5 min., on account of the instability of the milk when brought to the high, final sterilization temperature of 260° F.

The come-down intermediate holding period was at the same temperature and for the same duration of time as the corresponding come-up intermediate holding period in each series, but produced strikingly different results. In no case was the viscosity increased significantly as a result of the inclusion of a come-down holding period, and only samples from Series A, stored for 4 mo. at 70° F., showed significantly less separation of immiscible material as compared with samples from the single-stage process. In all other samples, there was no significant reduction in the amount of separation resulting from use of a come-down holding period. Thus, the advantage claimed for the come-down holding period in the patent *(8)*, could not be substantiated in these experiments.

There was some variation with respect to the effect of the intermediate holding period on the color of evaporated milk. The come-down holding period produced a darker color in the milk than the corresponding come-up intermediate holding period, as is shown by the lower L-values and higher b_L-values measured on the Hunter color meter immediately after sterilization and after storage at 70° F. (Tables 3, 5, and 7). The darker color as measured by the Hunter color meter was not usually detectable by the naked eye. Some of the differences in color were significant, as shown by the F-values marked with asterisks (Tables

TABLE 5
Effect of sterilizing evaporated milk on its color immediately after sterilization and after storage[a]
(At 250° F. using come-up and come-down holding periods)

Series B sterilization treatment	Hunter meter L-value			Hunter meter b_L-value		
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
250° F/7 min.	81.5	78.4	80.4	16.0	21.1	18.6
200° F/10 min.[b] 250° F/7 min.	81.5	78.4	80.1	16.1	21.2	18.8
250° F/7 min.[c] 200° F/10 min.	79.9	79.1	79.7	16.5	20.6	19.2
L.S.D.[d] P = 0.05	0.50	.....	0.37	0.19	.....	0.57
F-value	30.21**	....	4.48*	17.75**	....	2.10[N.S.]

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
* Difference significant at the 0.05 level.
** Difference significant at the 0.01 level.
N.S. Difference not significant.

3, 5, and 7), but the differences in color cannot be considered as being of any economic significance.

In order to equate the sterilizing value of a two-stage process with that of the corresponding regular single-stage process, it was considered feasible to reduce the duration of the holding period at the final sterilization temperature, to allow for the sterilizing value of the intermediate holding period. However, due to the infinitesimally small lethal rates of temperatures below 220° F., as compared with those of temperatures above 240° F., as quoted by Schultz and Olson *(20)*, the sterilizing value of the intermediate holding period was found to be very small in relation to the sterilizing value of the final sterilization stage. The values for lethal rates were calculated assuming a straight-line thermal death-time curve passing through the point 1 min. at 250° F., so that area under the lethality curve, in terms of the unit-sterilizing area, gave the sterilizing value of the process directly. Until a more satisfactory method of comparing the sterilization processes can be applied, than that of Bigelow *et al. (3)* which uses lethal rates, it is not considered feasible to attempt to shorten the holding time at the final sterilization temperature, to account for the sterilizing effect of the intermediate holding period. Ball *(1)* suggested that an evaluation of the effect of heat upon organoleptic and nutritive factors would be more appropriate than evaluation on the basis of lethal effect on microorganisms, because the thermal destruction-time curves for vitamins and, according to present indications, color, have much higher slope values than thermal death-time curves for microorganisms. The color index method of process evaluation described by Nelson *(13, 14)*, and the observation by Burton *(4)* of a linear relationship between color change and the rate of heat coagulation of evaporated skimmilk, may find application in similar studies.

TABLE 6

Effect of sterilizing evaporated milk on its viscosity and storage stability[a]
(At 260° F. using come-up and come-down holding periods)

Series C sterilization treatment	Viscosity			Immiscible material separation	
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
	(cp.)			*(%)*	
260° F/1 min.	23.8	11.4	9.5	5.6	5.5
200° F/5 min.[b] 260° F/1 min.	31.4	20.3	9.5	5.9	5.5
260° F/1 min.[c] 200° F/5 min.	22.5	14.1	9.7	5.3	5.0
L.S.D.[d] P = 0.05	4.16	7.78	0.47	0.81	0.90
F-value	11.75**	3.01 N.S.	0.66 N.S.	1.15 N.S.	0.73 N.S.

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
** Difference significant at the 0.01 level.
N.S. Difference not significant.

The two-stage holding method of sterilization appears to be of no particular value as a means of improving the storage stability of evaporated milk where high-short sterilization is employed. An increase in the holding time or in the temperature of the final sterilization stage in a high-short method will increase the viscosity of the sterilized product, but can readily lead to graininess in the milk. It is known that a number of the shifts in physical equilibria in milk which result from heating such as $Ca_3(PO_4)_2$ precipitation, are not instantaneous.

In addition, as has been reported by Simonson and Tarassuk *(16)*, with adequate holding time for the intermediate come-up holding period, the two-stage holding method of sterilization can reduce the tendency of gelation of the milk in the can, when sterilized at high temperatures and stored for moderately long periods. All samples sterilized in this series of experiments displayed some degree of age-thinning, and in no samples did gelation occur during storage up to 6 mo. at 70 and 100° F. It seems likely that the critical zone for gelation, as explained by Tarassuk and Tamsma *(19)*, is exceeded by the long come-up times employed in this study, enhanced by the inclusion of intermediate holding periods.

No information could be obtained as to the effect of the intermediate holding period in reducing the incidence of burn-on or smear-on deposits in the can, because these defects were not apparent in any cans examined after sterilization in the pilot retort. The absence of these defects may be attributed to the use of extended come-up times, which avoided sudden exposure of the can contents to high temperatures as commonly occurs in continuous sterilizers.

TABLE 7

Effect of sterilizing evaporated milk on its color immediately after sterilization and after storage[a]

(At 260° F. using come-up and come-down holding periods)

Series C sterilization treatment	Hunter meter L-value			Hunter meter b_L-value		
	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.	Immediately after sterilization	After storage 2 mo. at 100° F.	After storage 4 mo. at 70° F.
260° F/1 min.	83.2	78.1	81.6	15.0	20.5	17.3
200° F/5 min.[b] 260° F/1 min.	83.0	77.6	81.6	15.1	20.4	17.4
260° F/1 min.[c] 200° F/5 min.	81.6	78.8	81.1	15.6	20.8	18.1
L.S.D.[d] P = 0.05	0.30	.....	0.23	0.85	.....	0.20
F-value	78.36**	.....	12.69**	1.39[N.S.]	.....	50.20**

[a] Mean values of ten replicates.
[b] Come-up hold.
[c] Come-down hold.
[d] L.S.D. is least significant difference.
** Difference significant at the 0.01 level.
N.S. Difference not significant.

SUMMARY AND CONCLUSIONS

Evaporated milk was obtained at a Wisconsin evaporated-milk plant and sterilized in cans in a Berlin-type pilot retort. Three control sterilization processes, at 240, 250, and 260° F., were compared with two-stage processes in which deliberate pauses were introduced during either the come-up or the come-down stage of processing. The intermediate come-up holding stage was effective in increasing the viscosity measured immediately after sterilization, and in reducing the amount of fat and protein which separated out as a result of the subsequent decrease in viscosity which occurred when the milk was stored at high temperatures. The separated fat and protein material was estimated by a gravimetric method. The come-down intermediate holding period in two-stage holding sterilization was less effective than the come-up intermediate holding period, in improving storage stability of evaporated milk, and no significant advantage over the corresponding single-stage method was observed.

Color changes on sterilization were measured by means of a Hunter color meter, with which it was possible to detect differences in the depth of color resulting from inclusion of the intermediate holding period. The changes in color, which were statistically significant in some cases, were too small to be readily detected by the human eye. A darker color resulted from use of a come-down intermediate holding period than from use of a come-up intermediate holding period.

None of the samples from either single- or two-stage sterilization showed signs of burn-on or smear-on deposits, or of gelation on storage, due probably to the extended time of come-up to the sterilization temperature.

An attempt was made to evaluate the sterilization processes in terms of sterilizing values calculated from heat penetration data.

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REFERENCES

(1) Ball, C. O. Personal communication.

(2) Bell, R. W., Curran, H. R., and Evans, F. R. Effect of Temperature and Time of Sterilization upon the Properties of Evaporated Milk. *J. Dairy Sci.*, **27**: 913. 1944.

(3) Bigelow, W. D., Bohart, G. S., Richardson, A. C., and Ball, C. O. Heat Penetration in Processing Canned Foods. Nat'l. Canners' Assoc., *Bull.* 16L. 1920.

(4) Burton, H. A New Approach to the Problem of Heat Stability in Evaporated Milk. *Intern. Dairy Congr.*, **1**: (2): 342. 1956.

(5) Curran, H. R., Bell, R. W., and Evans, F. R. Temperature-Time Relationships for H.T.S.T. Sterilization of Evaporated Milk. *J. Dairy Sci.*, **27**: 909. 1944.

(6) Dean, M. P. Study of Factors Affecting the Physico-Chemical Properties of Evaporated Milk. Unpublished Univ. of Wisconsin thesis. 1955.

(7) Federer, A. E. The Effect of Methods of Sterilization on the Properties of Evaporated Milk. Unpublished Univ. of Wisconsin thesis. 1954.

(8) Food Machinery Corporation, San Jose, California. Method of Preparing Evaporated Milk and Like Products for Preservation in Sealed Containers. British Pat. No. 726,822, March 23, 1955, and U. S. Pat. Application No. 274,036.

(9) Hunter, R. H. Photoelectric Color-Difference Meter. *J. Opt. Soc. Am.*, **38**: 661. 1948.

(10) Maxcy, R. B., and Sommer, H. H. Fat Separation in Evaporated Milk. I. Homogenization, Separation, and Viscosity Tests. *J. Dairy Sci.*, **37**: 60. 1954.

(11) Maxcy, R. B., and Sommer, H. H. Fat Separation in Evaporated Milk. II. Age-Thinning of Concentrated, Sterilized Milk. *J. Dairy Sci.*, **37**: 306. 1954.

(12) Maxcy, R. B., and Sommer, H. H. Fat Separation in Evaporated Milk. III. Gravity Separation and Heat Stability. *J. Dairy Sci.*, **37**: 1061. 1954.

(13) Nelson, V. The Color of Evaporated Milk with Respect to Time and Temperature of Processing. *J. Dairy Sci.*, **31**: 415. 1948.

(14) Nelson, V. The Physical Properties of Evaporated Milk with Respect to Surface Tension, Grain Formation, and Color. *J. Dairy Sci.*, **32**: 775. 1949.

(15) Nelson, V. The Heat Stability of Evaporated Milk as a Function of the Steam and Hydrostatic Pressure Applied in the Forewarming of Milk. *J. Dairy Sci.*, **35**: 388. 1952.

(16) Schultz, O. T., and Olson, F. C. W. Thermal Processing of Canned Foods in Tin Containers. *Food Research*, **5**: 4. 1940.

(17) Simonson, H. D., and Tarassuk, N. P. Fluorescence and Associated Changes Produced upon Storage of Evaporated Milk. *J. Dairy Sci.*, **35**: 166. 1952.

(18) Tamsma, A. F., and Tarassuk, N. P. Reduction of the Fat Separation in Evaporated Milk. *J. Dairy Sci.*, **39**: 26. 1956.

(19) Tarassuk, N. P., and Simonson, H. D. Browning and Fluorescence of Evaporated Milk. *Food Technol.*, **4**: 88. 1950.

(20) Tarassuk, N. P., and Tamsma, A. F. Control of Gelation in Evaporated Milk. *J. Agr. & Food Chem.*, **4**: 1033. 1956.

(21) Webb, B. H., Deysher, E. F., and Potter, F. E. Effects of Storage Temperature on Properties of Evaporated Milk. *J. Dairy Sci.*, **34**: 1111. 1951.

EFFECTS OF FEEDING STILBESTROL TO LACTATING DAIRY COWS

T. R. WRENN AND J. F. SYKES
Dairy Cattle Research Branch, Nutrition and Physiology Section, Agricultural Research Center, Beltsville, Maryland

Diethylstilbestrol was fed daily for 60 days to 12 cows. Group 1 was fed alfalfa hay and corn silage; Group 2, grass-legume silage, and Group 3, alfalfa hay. Concentrate containing 15% protein was fed to the Holsteins at the rate of 1 to 4 lb. of milk, and to Jerseys, 1 to 3. Feeding from 10 to 15 mg. of the estrogen per day did not affect milk production. *Editor.*

The effects of estrogens on established lactations in dairy cattle were reviewed by one of us (J.F.S.) in 1953 *(5)*. Most of the past work has involved the administration of estrogenic materials by injection or implantation techniques.

The present investigation was prompted by the discovery *(2)* of marked improvements in the rate of gain and the efficiency of feed utilization, occasioned by the feeding of trace amounts of diethylstilbestrol to beef cattle. This paper is concerned with studies of the effect on the milk production of dairy cows of feeding similar amounts of diethylstilbestrol orally.

Preliminary reports on similar investigations have been reported by Browning *et al. (1)* and Sherman *et al. (4)*. The recent investigation of Turner, Yamamoto, and Ruppert *(7)* has recorded effects of stilbestrol feeding to heifers with induced lactations. A portion of the work reported in this paper was included in a preliminary report *(6)* from this laboratory.

EXPERIMENTAL PROCEDURE

Diethylstilbestrol was fed daily for 60-day periods to a total of 12 cows. The hay and silages fed differed among cows and for this reason the cows were regrouped as follows: Three cows, Group 1, were fed a ration of alfalfa hay and corn silage; three cows comprising Group 2 were fed grass-legume silage, and the six cows of Group 3 were fed alfalfa hay. All cows were fed a 15% protein concentrate in amounts dependent upon milk production. The concentrate was fed at the rate of 1 lb. of concentrate to 4 lb. of milk for the Holsteins, and at the rate of 1:3 for the Jerseys.

Diethylstilbestrol was fed by the daily addition of a corn oil solution of the material to the feed concentrate. All cows of Groups 1 and 2 received stilbestrol at the rate of 10 mg. per day. The Jersey cows of Group 3 were fed 10 mg. of stilbestrol per day and the Hosteins of this group received 15 mg.

The average number of days in milk for cows of the three groups at the time stilbestrol feeding was started was as follows: Group 1, 137 days; Group 2, 231 days, and Group 3, 132 days.

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RESULTS AND DISCUSSION

Data on milk production, feed consumption, and body weight change are shown (Table 1 and Figure 1). One cow in Group 3 developed a severe foot infection during the course of the trial; data on this cow are not included, because of the marked decrease in feed consumption and milk production which occurred during the infection.

Examination of the individual milk production curves (Figure 1) gives no indication that feeding stilbestrol increased or decreased lactation in any way. The marked drop in production which occurred in Group 2 toward the end of the stilbestrol-feeding period was due to a decrease in feed consumption (see subsequent discussion of Group 2's feed consumption) and can not be considered to be an effect of stilbestrol. The fat percentage of the milk was not changed (see Table 1).

Persistency of milk production (Table 1) appears to have been decreased in Group 2, but this must be discounted because of the poor feed consumption observed for a short period in this group. In the two other groups, persistency of production was not affected by feeding stilbestrol.

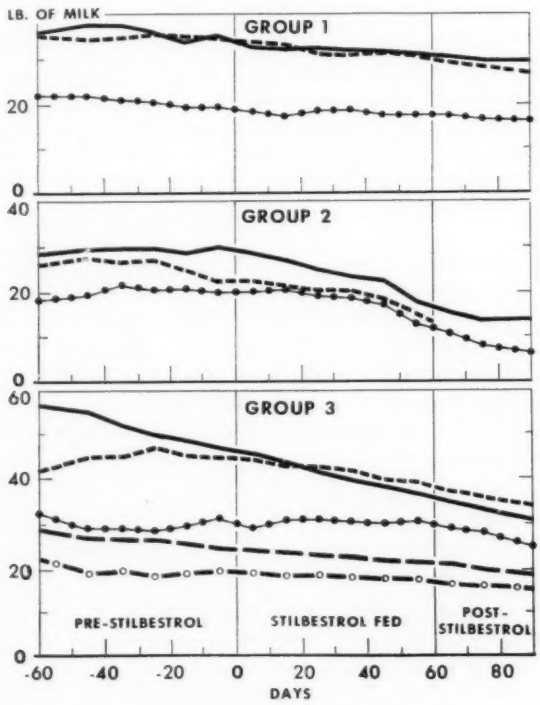

FIG. 1. Milk production of cows fed stilbestrol.

TABLE 1

Effects of feeding diethylstilbestrol on milk production, dry matter feed consumption, and weight gains of dairy cows

Period	Milk fat	Decrease[a] in milk production	Dry matter consumed	Body weight increase
	(%)		(lb/cow/day)	
Group 1—Three cows fed alfalfa hay and corn silage				
60 days prestilbestrol	4.46	6.7	26.4	0.62
60 days with stilbestrol	4.50	11.3	26.3	0.85
30 days poststilbestrol	4.71	7.0	24.6	0.19
Group 2—Three cows fed grass-legume silage				
60 days prestilbestrol	4.13	1.7	24.8	0.50
60 days with stilbestrol	4.28	37.3	20.9	0.80
30 days poststilbestrol	4.52[b]	36.1[b]	18.8	1.42
Group 3—Five cows fed alfalfa hay				
60 days prestilbestrol	4.43	9.9	30.7	0.69
60 days with stilbestrol	4.27	11.4	35.0	0.68
30 days poststilbestrol	4.29	12.9	32.6	1.08

[a] This is an expression of the reduction in the average daily production for the last ten days of the period, as compared with the average daily yield for ten days before the period began.

[b] Based on the average of only two cows (it became necessary to dry up one cow because of its advanced pregnancy).

Body weight gains were well maintained throughout the experimental period (Table 1). In Groups 1 and 2, gains were actually improved during the stilbestrol-feeding period and, in Group 3, the increase in the 30-day poststilbestrol period may be a carry-over effect. The marked increase in gain in Group 2 during the poststilbestrol period is undobutedly complicated by the fact that these cows were closer to parturition at this time than were the cows in Groups 1 and 3. The decrease in rate of gain in the poststilbestrol period in Group 1 occurred for no apparent reason, unless it could be assumed to be the result of withdrawal of stilbestrol. The above observations offer some slight suggestion that stilbestrol feeding may have improved weight gains. Some decrease in body weight might have been expected for most of these cows, during part of the experimental period, at least.

Similarly, feed consumption was maintained at very satisfactory levels except in Group 2 (Table 1). In this group, feed consumption decreased rapidly during the last few days of the stilbestrol-feeding period. When the source of silage was changed, feed consumption was improved. Therefore, the quality of silage, rather than stilbestrol feeding, was apparently responsible for this observation. In Group 3, feed consumption actually increased when stilbestrol was fed and was maintained at a high level during the poststilbestrol period.

The above observations on body weight and feed consumption suggest that stilbestrol may have had effects similar to those observed in beef cattle. In spite of this, there is no indication that stilbestrol feeding had any effect on the level or persistency of milk production.

These observations agree with those of Sherman *et al. (4)*, who reported no effect of stilbestrol on milk production (although many of the details are lacking).

Browning *et al.* *(1)* have reported some slight increase in production from feeding stilbestrol to identical twins, but their work with other cows was inconclusive. The recent report of Turner, Yamamoto, and Ruppert *(7)*, in which an increase in persistency was reported, can not strictly be compared to the present work, or to that of Browning *et al.* or of Sherman *et al.*, because stilbestrol was fed to animals in which udder development and lactation had been induced by hormonal treatments and the lactation performance of such animals is unpredictable.

The recent report of Pieterse and Andrews *(3)*, on the relatively high estrogenic activity of alfalfa silages, suggested that some differences in response to stilbestrol feeding might be observed between animals fed a grass-legume silage ration (Group 2) and those fed hay or hay and corn silage rations (Groups 1 and 3). Evidence that such is the case was not obtained in the present work.

The feeding of daily amounts of 10 and 15 mg. of stilbestrol to the cows in this experiment did not produce any physical abnormalities or undesirable side-effects in reproductive activities.

SUMMARY

The effects of feeding diethylstilbestrol to milking cows have been investigated. No detectable effect on milk production was observed when 11 cows were fed from 10 to 15 mg. of stilbestrol per day for periods of 60 days.

REFERENCES

(1) Browning, C. B., Marion, G. B., Fountaine, F. C., and Geir, H. T. Some Effects of Feeding Diethylstilbestrol to Dairy Cattle. *J. Dairy Sci.*, 39: 924. 1956.

(2) Burroughs, W., Culbertson, C. C., Kastelic, J., Cheng, E., and Hale, W. H. The Effects of Trace Amounts of Diethylstilbestrol in Rations of Fattening Steers. *Science*, 120: 66. 1954.

(3) Pieterse, P. J. S., and Andrews, F. N. The Estrogenic Activity of Legume Grass and Corn Silage. *J. Dairy Sci.*, 39: 81. 1956.

(4) Sherman, W. C., Adams, C. R., Reynolds, W. M., and Luther, H. G. Safety Considerations in Using Diethylstilbestrol as a Growth Promotant in Feeder Cattle. *J. Animal Sci.*, 14: 1255. 1955.

(5) Sykes, J. F. In *Hormonal Relationships and Applications in the Production of Meats, Milk, and Eggs.* National Research Council Publication No. 266. p. 41. 1953.

(6) Sykes, J. F., Wrenn, T. R., Kane, E. A., and Jacobson, W. C. Effect of Feeding Stilbestrol to Lactating Dairy Cows. *J. Dairy Sci.*, 39: 925. 1956.

(7) Turner, C. W., Yamamoto, H., and Ruppert, H. L., Jr. Endocrine Factors Influencing the Intensity of Milk Secretion. A. Estrogen, Thyroxine, and Growth Hormone. *J. Dairy Sci.*, 40: 37. 1957.

GROWTH AND THERMAL DESTRUCTION OF *MICROCOCCUS PYOGENES* VAR. *AUREUS* IN HEATED AND RAW MILK

B. HEINEMANN

Producers Creamery Company, Springfield, Missouri

This study was undertaken to determine if Micrococcus pyogenes var. aureus would grow in raw milk. It was found that raw milk did not provide a favorable environment for the growth of this organism, but that it grew well at 80 to 115° F. in pasteurized skimmilk and in condensed skimmilk, containing 42% total solids. Difco's Staphylococcus Medium 110 can be used to detect postpasteurization contamination of micrococci similar to enterotoxigenic strains. *Editor.*

Anderson and Stone *(2)* and Hobbs *(4)* reported an outbreak of typical staphylococcal food poisoning in England, owing to the consumption of nonfat dry milk. They indicated that enterotoxin could be produced either in the raw milk or in the condensed milk before drying. Since the enterotoxin is heat-stable, once produced it survives the usual heating employed in the dairy industry.

The work reported here was undertaken to determine the extent that raw milk would support the growth of *Micrococcus pyogenes* var. *aureus*. Since the strains employed were enterotoxigenic, it was inferred that toxin production paralleled the growth of the organism.

METHODS

Cultures of *M. pyogenes* var. *aureus* were obtained from the U. S. Public Health Service Laboratory in Cincinnati. These were designated 196E, 161C, and S6, and were reported to be enterotoxigenic *(7)*. These cultures were carried in sterile skimmilk and used when from 18 to 24 hr. old.

The medium used for making total bacterial estimates was Milk Protein Hydrolysate Glucose Agar *(1)*. Difco's Staphylococcus Medium 110 *(3)* was used for estimating the salt-tolerant bacterial population. The three strains of the test organism grew well on Medium 110, and a reasonably good agreement was obtained when bacterial estimates were made on the pure cultures, using both MPH and 110 media.

The raw skimmilk was obtained by the separation of both Grade "A" and manufacturing-grade milk. The milk was separated at 90° F. and promptly cooled to 40° F. until used. One ml. of the *M. pyogenes* culture was added to 100 ml. of sterile skimmilk. One ml. of this dilution was then added to 100 ml. of raw skimmilk. Portions were incubated at from 50 to 125° F. for from 8 to 12 hr., standard bacterial estimates and bacterial estimates using Medium 110 were made, and these plates incubated 48 hr. at 95° F. All visible colonies were counted on all plates.

In the thermal death-time studies, skimmilk was used with a standard bacterial estimate of approximately 50 million per ml. About 2 ml. of this culture

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was sealed in tubes and the tubes submerged in a water-bath at the required temperature. The thermal death time was calculated by the procedure of Webster and Esselen *(6)*, using a lag time of 1.0 min. This same general technique was used to determine the effect of pasteurization and of differential heating on the growth of naturally occurring salt-tolerant micrococci in raw milk. Samples of Grade A raw milk were sealed in tubes and submerged in a water-bath for various times and temperatures. Following heating, the samples were incubated for from 8 to 18 hr. at 95 to 110° F. Plate counts were then made on MPH and 110 media. Since Tellurite-Glycine Agar *(9)* appeared to have merit as a confirmatory medium, some studies were made using it.

RESULTS

The thermal death time of Culture 196E in skimmilk is given (Table 1). The thermal death-time curve has a z value of 9.2. Cultures 161C and S6 did not survive 10 min. at 143° F., but the thermal death times were not determined for

TABLE 1

Thermal death point of M. pyogenes var. *aureus*

Culture 196E in skimmilk

Temp. °F.	Time (min.)	Time [a] (poultry stuffing)
135	80	100
140	24	16
145	6.8	6
150	1.9	2.5
161 (extrapolated)	0.14	0.32

[a] Data of Webster and Esselen *(6)*, using Culture 9664 (A.T.C.C.).

these two cultures. These three enterotoxigenic cultures did not survive the usual pasteurization heat treatment.

Myhr and Olson *(5)* have shown that 13 out of 39 strains of micrococci, isolated from raw milk as delivered to a plant, survived pasteurization. Consequently, a study was made to determine if any salt-tolerant micrococci naturally present in raw milk would survive laboratory pasteurization. Grade A raw milk samples from individual herds were taken as the milk was delivered to the plant. The raw milk was plated and then pasteurized at 143° F. for 30 min. On 107 samples, the bacterial estimate of the raw milk obtained on Medium 110 ranged from 300 to 39,000 per ml., with 12% of the samples exceeding 10,000. The average was 4,900 per ml. After pasteurization, 1 ml. was plated, using Medium 110, and no colonies developed which were coccus types, as determined by microscopic examination. Those organisms which were growing on the plates were rods. These colonies were transferred to sterile skimmilk, incubated, and the skim repasteurized, to ascertain if the organisms could have been contaminants. Some survived pasteurization. These cultures were not further identified, but were streaked on Tellurite-Glycine Agar plates directly from plates containing Medium 110. After 24 hr. of incubation, black colonies developed. Microscopic examination of these colonies showed them to be rods. It

was noted that these rods produced only black colonies on the Tellurite-Glycine Agar, when streaked directly from Medium 110. By transferring from Medium 110 to MPH agar and then to the Tellurite-Glycine Agar, no growth occurred. This intermediate step reduces the usefulness of Tellurite-Glycine Agar as a confirmatory medium for micrococci in plant control work.

The number of colonies developing from plating 1 ml. of pasteurized Grade A milk on Medium 110 was generally less than 20 per ml., and frequently zero. For plant control purposes, using Medium 110 on pasteurized products, yellow colonies may be taken as evidence of postpasteurization contamination, but should also be checked microscopically to be certain they are micrococci. It does appear, however, on the basis of the trials reported above, that the salt-tolerant micrococci naturally occurring in milk do not survive pasteurization in numbers of 1 per ml. or greater.

A number of trials were made in which raw skimmilk was inoculated with Cultures 196E, 161C, and S6. No significant growth differences among cultures were observed. Grade A skimmilk was used, as well as manufacturing grade, and no appreciable difference was noted in the relationship between growth on MPH and on Medium 110 between grades of milk. Table 2 presents the arithmetic average of bacterial estimates of four trials. One trial consisted of Culture

TABLE 2

Growth of M. pyogenes var. *aureus in inoculated raw skimmilk (av. of four trials)*

Temp. held	8-hr. incubation		12-hr. incubation	
	MPH(1)[a]	110 (2)[b]	MPH(1)[a]	110 (2)[b]
50	3,140,000	44,800	17,300,000	36,000
60	18,300,000	49,000	51,700,000	43,800
70	106,000,000	63,800	276,000,000	67,000
80	118,000,000	75,500	425,000,000	108,000
95	248,000,000	247,000	1,170,000,000	353,000
110	340,000,000	1,120,000	413,000,000	3,300,000
115	33,700,000	465,000	284,000,000	294,000
125	47,700	3,000	1,030,000	14,000

The estimate after inoculation, but before incubation, averaged 1,270,000/ml, using the MPH medium, and averaged 61,500/ml using the 110 medium.

[a](1) Total bacterial estimate on Milk Protein Hydrolysate agar.

[b](2) Total bacterial estimate on Difco Medium 110.

196E and Grade A skim; the second, of Culture 196E and manufacturing-grade skim; the third of Culture 161C and Grade A skim, and the fourth of Culture S6 and manufacturing-grade skim. These results show that these strains grow poorly in raw milk at temperatures of 80° F. or lower. There was a tendency for their numbers to decrease at storage temperatures of 60° F. or lower and 125° F. and higher. Incubation temperatures of about 110° F. appeared to be optimum, but even at this temperature, the natural flora of milk quickly overgrew the three strains used. There was a decrease in both total population and salt-tolerant micrococci after 8 hr. at 125° F., followed by a slight increase after 12 hr.

It was noted (Table 2) that the incubation temperature of 125° F. resulted

TABLE 3

The effect of differential heating of raw milk on the growth of salt-tolerant micrococci

Treatment	Immediately after heating		Hold 18 hr. at 95° F. (after heating)	
	MPH (2)[b]	110 (3)[c]	MPH (2)[b]	110 (3)[c]
			(million)	
Raw (1)[a]	.....	.....	600	9.0
125° F. for 5 min.	55,000	14,000	500	5.3
125° F. for 15 min.	51,000	10,000	440	5.0
125° F. for 30 min.	44,000	9,000	360	1.2

[a](1) Bacterial estimate before heating was: MPH, 250,000; 110, 14,000.
[b](2) Bacterial estimate using Milk Protein Hydrolysate.
[c](3) Bacterial estimate using Difco Medium 110.

in a pronounced decrease in both total estimates and the estimates using Medium 110 after 8 hr., followed by an increase during the subsequent 4-hr. incubation period. It was assumed, therefore, that heating raw milk at lower than pasteurization temperatures might destroy many species, leaving the more heat-resistant, salt-tolerant micrococci. Subsequent incubation would then result in their preferential growth. Such an assumption, however, could not be verified. Various preliminary heat treatments from 125° F. for 5 min. to 143° F. for 10 min. were tried, followed by incubation at 95 or 110° F. Table 3 presents the results of one trial, employing such a differential heat-treatment of the skimmilk. One experiment was conducted with raw milk inoculated with Culture 196E and, in this case, preliminary heating did result in a slightly improved micrococci population increase. In the unheated sample, 4.0% of the total population was micrococci after 14 hr. of incubation at 95° F., and 10.3% of the total population was micrococci after incubation, when the sample was given a preliminary heat-treatment of 125° F. for 30 min. This result was not considered to be of any practical significance.

In contrast with the limited growth of the enterotoxigenic cultures in raw or partially heated skimmilk, growth was found to be very rapid in condensed skimmilk held at 95° F. The condensed milk used was made from skimmilk

TABLE 4

Growth of M. pyogenes var. *aureus in pasteurized, inoculated skim, condensed milk*

Culture used	Total solids	Bacterial estimate per ml. Before incubation		Held 24 hr. at 95° F.	
		MPH (1)[a]	110 (2)[b]	MPH (1)[a]	110 (2)[b]
	(%)			*(million)*	
	29.02	18,000	18,000	260	240
161C	33.96	15,000	19,000	260	280
	38.63	16,000	14,000	630	460
	42.77	14,000	10,000	540	320
	31.71	90,000	84,000	1,400	1,500
	33.51	53,000	64,000	980	1,200
196E	35.56	87,000	74,000	740	720
	38.54	53,000	56,000	570	580

[a](1) Total bacterial estimate on Milk Protein Hydrolysate agar.
[b](2) Total bacterial estimate on Difco Medium 110.

preheated at 205° F. for 20 min. prior to condensing. Some of the results obtained are shown (Table 4). Bacterial estimates made on skimmilk pasteurized at 143° F. for 30 min., then inoculated with the enterotoxigenic cultures, are about the same magnitude as those reported (Table 4). Populations of the organism reached 40 to 100 million per ml. in the pasteurized skimmilk in from 6 to 10 hr. at 95° F.

SUMMARY

In order for raw milk to be the source of toxin, enterotoxigenic strains of *Micrococcus pyogenes* would have to grow in raw or partially heated milk. The results reported here do not support this view. Nor does it appear likely that raw milk is the source of the organisms involved, unless the pasteurized product were to become contaminated by raw milk. Although salt-tolerant micrococci appear to be widely spread in raw milk, pasteurization reduces their numbers to less than 1 per ml.

Pasteurized skimmilk or condensed skimmilk up to at least 42% total solids serves as an excellent medium, and enterotoxigenic strains multiplied rapidly at 95° F. Since they were found to grow over the range of 80 to 115° F., prolonged holding of pasteurized products at these temperatures must be avoided.

Since few, if any, salt-tolerant yellow micrococci naturally present in milk survive pasteurization, Medium 110 may be used as a plant control measure on pasteurized products, to detect possible postpasteurization contamination and subsequent growth of micrococci similar to enterotoxigenic strains.

REFERENCES

(1) American Public Health Association, Inc. *Standard Methods for the Examination of Dairy Products.* 10th ed. American Public Health Association, Inc. 1953.

(2) Anderson, P. H. R., and Stone, D. M. Staphylococcal Food Poisoning Associated with Spray-Dried Milk. *J. Hyg.*, **53**: 387. 1955.

(3) Difco Laboratories. *Difco Manual.* 9th ed. Difco Laboratories, Detroit, Michigan. 1953.

(4) Hobbs, Betty C. Public Health Problems Associated with the Manufacture of Dried Milk. I. Staphylococcal Food Poisoning. *J. Appl. Bact.*, **18**: 484. 1955.

(5) Myhr, A. N., and Olson, J. C., Jr. A Study of Thermal Resistance of Micrococci in Milk. *J. Dairy Sci.*, **39**: 1635. 1956.

(6) Webster, R. C., and Esselen, W. B. Thermal Resistance of Food Poisoning Organisms in Poultry Stuffing. *J. Milk and Food Technol.*, **19**: 209. 1956.

(7) Wilson, Elizabeth. Personal communication. U. S. Public Health Service, Cincinnati, Ohio. 1956.

(8) Zebovitz, E., Evans, J. B., and Niven, C. F., Jr. Tellurite-Glycine Agar: A Selective Plating Medium for the Quantitative Detection of Coagulase-Positive Staphylococci. *J. Bacteriol.*, **70**: 686. 1955.

MILK RESPONSE FROM FEEDING DIETHYLSTILBESTROL TO IDENTICAL-TWIN COWS DURING COMPLETE LACTATIONS[1]

C. B. BROWNING, F. C. FOUNTAINE, G. B. MARION, AND F. W. ATKESON
Department of Dairy Husbandry, Kansas Agricultural Experiment Station, Manhattan

Effects on milk production of feeding low levels of diethylstilbestrol (DES) to five pairs of identical-twin cows were studied. Each cow fed DES produced more 4% FCM than the control, but in one pair the difference was not significant at the 5% level. Except in one pair, cows fed DES gained less weight than the controls and were about 6% more efficient producers of 4% FCM. *Editor.*

Lush green pasture has been long recognized as having a stimulating effect on milk production. The possibility that plant estrogens are associated with this effect was suggested by Bartlett and coworkers *(1)*. Many workers *(5, 6, 9-11, 16, 22)* have used diethylstilbestrol or related compounds to induce udder growth and lactation in dairy animals.. Also, work has been conducted to determine the galactopoietic effects of estrogenic materials on lactating cows *(7, 8, 12, 20)*. In recent years, the feeding of stilbestrol-supplemented feeds to beef cattle has become economically important *(3, 18, 19)*.

The study reported here was undertaken to determine the effects on milk production of feeding low levels of diethylstilbestrol to dairy cows.

EXPERIMENTAL PROCEDURE

Before setting up the principal experiment, 17 cows from the Kansas State College dairy herd were used in a preliminary study, to determine the optimal level of diethylstilbestrol (DES) that would stimulate milk production. The animals selected for this study were in various stages of gestation and lactation. They were fed DES at levels ranging from 0 to 15 mg. per 1,000 lb. of body weight per day. It was not expected that these animals would yield comparable data on production response, because of variation in lactation, gestation, and age. Some cows were not pregnant. From the data collected, however, it was concluded that the 10-mg. level of DES feeding, initiated 60 days postpartum, was the most satisfactory level.

Five pairs of identical-twin cows were used in the principal study. Two pairs of the twins were producing in their first lactation, one pair in their second, and two in their third. All but one pair of twins was purchased specifically for this study. No record of previous treatment or of production was available on these twins, but it was assumed that treatment was uniform within pairs.

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One pair (No. 4) was obtained from the Kansas State College herd and had been used on an experiment comparing urea with vegetable protein during their first lactation. During this previous lactation, Twin 40A produced 626 lb. more 4% FCM than did her twin-mate. This cow was assigned by random selection to the control group in the stilbestrol experiment. Except for Pair No. 3, the within-pair difference in calving dates was less than 20 days. The difference in calving dates in Pair No. 3 was 50 days; however, both cows calved in cool weather, so that their lactations were completed under similar environmental conditions. During the first 56 days of lactation, a uniformity trial was conducted. All of the cows were fed the control ration during this period. Beginning on the 57th day postpartum, and continuing for the remainder of the lactation, one cow selected at random from each twin-pair was fed a ration containing DES; whereas, the other twin of each pair received the same ration without DES. DES was fed at the level of 10 mg. per 1,000 lb. of body weight daily.

Management of experimental animals. The cows were housed in an experimental barn and turned out into a dry lot twice daily for exercise. They were milked twice a day by the same person throughout the entire experiment. Daily milk weights were recorded, and the milk produced during a 48-hr. period was sampled for butterfat and solids-not-fat determinations at the end of each 14-day period. Body weights were also recorded at the end of each 14-day period. All hay, silage, and concentrate mixture fed to, and refused by, each cow was carefully weighed and recorded.

Feeding methods. Alfalfa hay was fed to each cow at a rate that would result in approximately 10% weigh-back daily. Sorgo silage was fed at the rate of 2 lb. per 100 lb. of body weight. A 17% protein concentrate mixture was fed at a rate of 1 lb. for each 3.5 lb. of 4% fat-corrected milk (14) produced. DES was provided in a commercial premix.[2] The quantity of concentrate mixture fed was adjusted each 14th day, according to the production of the previous 14-day period. The treated cows received DES once daily at the afternoon feeding as part of the concentrate mixture. The quantity of concentrate containing DES that was fed was also adjusted on the 14th day of each period, according to body weight.

RESULTS AND DISCUSSION

Milk production. During the base period of 56 days postpartum, two of the five twin animals scheduled to receive DES produced at a higher level than did their twins that were to remain on the control ration. However, only in Twin Pair No. 4 was the difference in mean daily production significant ($P < .001$) (Table 1). During the period of DES intake, the treated cow of each pair produced more 4% FCM in all five pairs than did the control cow; however, the difference for one pair (No. 3) was not significant at the 5% level. The administration of DES did not result in the same percentage increase in milk production by all treated cows. Although there was a variation in response, the results were pooled in order to make a comparison between the treated and

[2] Supplied by Eli Lilly and Company, Indianapolis, Ind.

TABLE 1

Effects of diethylstilbestrol (DES) on fat-corrected milk and milk solids production of identical-twin cows

Pair No.	Cow No.	DES fed daily	Production of FCM				Average fat test		Average total solids test	
			Base[a] period	Treated[b] as % of control	Test period[c]	Treated as % of control	Base period	Test period	Base period	Test period
		(mg/1,000 lb. body wt.)	*(lb.)*	*(%)*	*(lb.)*		*(%)*			
	81	0	714		3,749		4.1	5.4	13.50	14.94
1	82	10	817	114	4,732	126	4.2	5.4	13.80	14.94
	84	0	1,044		742		4.5	4.5	13.90	13.83
2	83	10	1,036	99	795	107	4.5	4.5	13.70	13.73
	86	0	996		2,074		5.3	5.2	15.30	15.50
3	85	10	992	99	2,234	108	4.9	5.5	14.22	14.80
	40	0	1,127		4,162		3.8	4.1	12.85	12.98
4	41	10	1,367	121	4,981	120	3.9	4.2	12.99	13.16
	194	0	1,715		7,258		3.4	3.4	11.56	11.62
5	195	10	1,709	99	8,596	118	3.1	3.6	11.01	11.65
Pooled av:	Control		1,119		3,597		4.2	4.5	13.42	13.77
	Treated		1,184	106	4,268	119	4.1	4.8	13.14	13.66

[a] First to 56th day of lactation. All animals fed control ration during this period.

[b] Treated during base period refers to the animal of each pair that was scheduled to receive treatment.

[c] The test period was the remainder of the lactation; the length for each pair, in weeks, was as follows: Pair 1—36, 2—9, 3—28, 4—34, and 5—36.

control groups. When the production records of the cows to be treated were pooled and compared with the pooled production of the control cows, there was a 6% difference in favor of those to be treated. However, during the period of DES intake, a 19% difference in favor of the treated cows was obtained (Table 1).

During the test period, the decline in production was less for the treated cows than for the controls, except in the case of Twin Pair No. 4. In this pair, the treated cow produced more 4% milk but had a greater decline than did the control cow. The differences in decline, as measured by linear regression coefficients, were significant at the 5% level except for Twin Pair No. 2, in which the period of treatment was so short, due to the accidental death of the treated animal, that there was no significant ($P > .50$) decline in production for either animal. As shown (Figures 1 and 2), the greater milk production of the treated animals was the result of greater persistency in all but Twin Pair No. 4. The production of Pair No. 2 is not shown in graphic form, since their lactations were incomplete.

There has been little work reported to date on the effects of feeding DES to dairy cows, and that reported is conflicting. Foreman and Porter *(13)* found

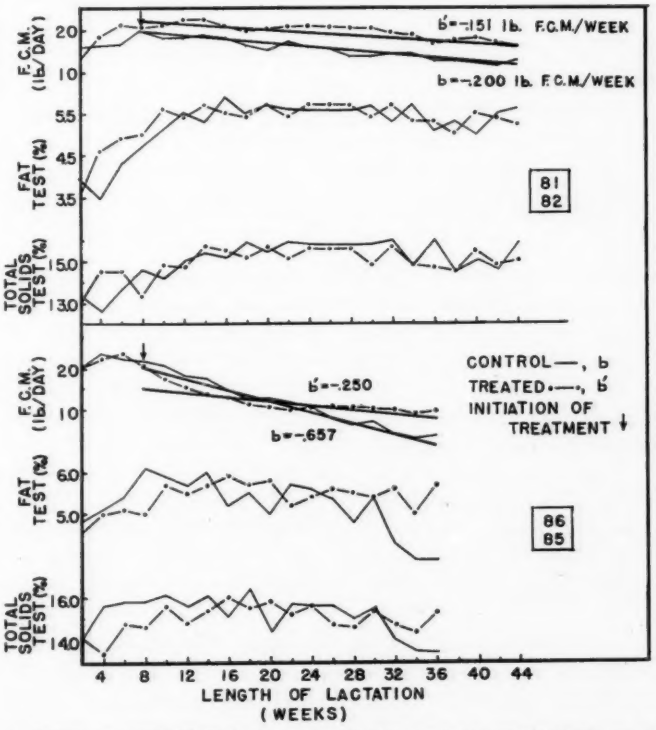

FIG. 1. Effect of diethylstilbestrol (10 mg/1,000 lb. body weight/day) on the level of 4% FCM production, butterfat test, and total solids test of identical-twin cows.

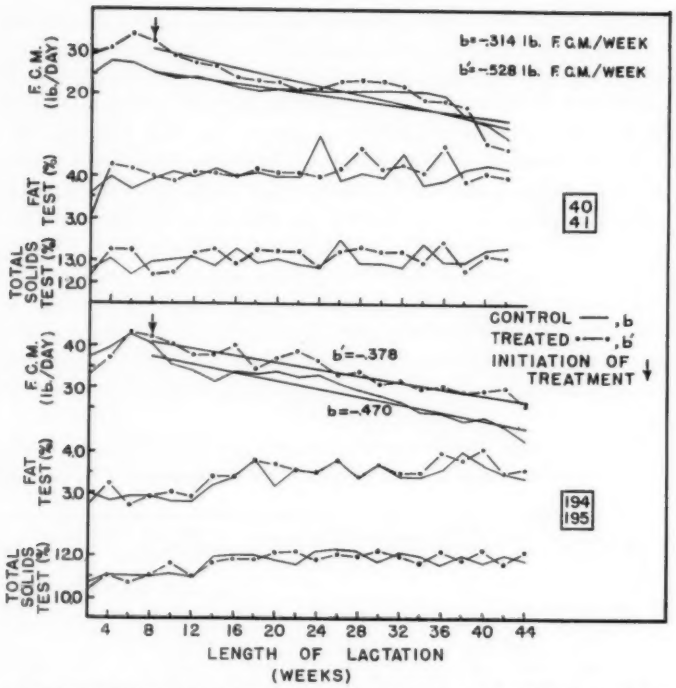

FIG. 2. Effect of diethylstilbestrol (10 mg/1,000 lb. body weight/day) on the level of 4% FCM production, butterfat test, and total solids test of identical-twin cows.

that feeding 10 mg. of DES daily seemed to increase persistency in milk production in five dairy cows. Turner *et al. (23)* suggest, from their work with heifers artificially induced to lactate, that the feeding of 10 mg. of DES daily after cows have reached their peak of production will tend to arrest the rate of decline. Sykes and coworkers *(21)*, however, reported no effect on persistency of milk production in six cows receiving 10 mg. of DES daily for 60 days. There were no controls in their experiment. This is not in harmony with the findings of this study, since greater milk production of the identical twins receiving DES was attributed to increased persistency. Also, there appeared to be very little, if any, initial stimulatory effect on production when treatment was started at 57 days, but the effect of DES on persistence of production appears to have increased average total yield of FCM approximately 13% in the cows receiving DES.

Per cent butterfat and total solids produced. The average per cent of fat and total solids for each animal is presented (Table 1). The trends in butterfat and the total solids content of the milk are also shown (Figures 1 and 2). From these data, it seems apparent that feeding 10 mg. of DES per 1,000 lb. of body weight daily did not influence the butterfat or solids-not-fat percentage of the

milk produced. Folley *(8)* reported an increase in the per cent of fat and solids-not-fat in the milk of three cows receiving injections of estrogenic hormones. There was a temporary drop in production in these animals. Folley and coworkers *(12)* later reported an increase in solids produced by cows treated with estrogen, but no marked effect on production. Spielman *et al. (20)* reported similar results.

It has been established that high levels of estrogen inhibit milk production. Mixner *et al. (17)* found that injections of 2.0 to 4.0 mg. of DES per day inhibited milk production in goats.

Because production seemed to be stimulated and there was no apparent effect on the solids content of milk produced by the cows that received DES during the study reported here, and because the cows were on comparatively low levels of orally administered DES, the level necessary for stimulation of production may fall below the quantity that causes inhibition of lactation, or an increase in the solids content of the milk.

Body-weight changes. Generally, the cows receiving DES gained less in body weight than did the control cows. In only one pair (No. 5) was there a greater increase in body weight by the treated animal than by the control animal during the experimental period (Table 2).

Efficiency of production. Clegg and Cole *(4)* reported an increase in feed utilization by beef steers receiving DES implants, and Burroughs *et al. (3)* have reported that steers receiving DES orally had an increase of 11% in feed efficiency, and an increased feed consumption of approximately 5%. A comparison of the efficiency of production of 4% FCM by the identical-twin cows used in this study is presented (Table 2). Gross efficiency was calculated as the ratio of FCM to total digestible nutrients (TDN) consumed:

$$\text{Gross efficiency} = \frac{\text{lb. FCM produced}}{\text{lb. TDN consumed}}$$

When the data on gross efficiency for the base period were pooled, there was a 9% difference in favor of the twin cows scheduled to receive DES. During the period of DES intake, these same animals were 15% more efficient. A comparison of gross efficiency between the base period and the test period (Table 2) indicates there was increased gross efficiency of production in all but Twin Pair No. 4. Greater gross efficiency in conversion of feed to milk was obtained by the treated animal in all twin pairs.

Data on efficiency of production obtained by adjusting for body-weight changes during the period of DES administration are also presented (Table 2). The adjustment was made by correcting the amount of TDN intake *(15)* to that portion theoretically used only for the production of milk. When body-weight changes were considered, the differences in efficiency between treated and control cows were less (in all but Pair No. 5) than when weights were not considered. This was a result of the control cow gaining more weight during the experimental period than the treated cow (except for Pair No. 5). However,

TABLE 2

Effects of diethylstilbestrol (DES) on body-weight changes and efficiency of production of identical-twin cows

Pair No.	Cow No.	DES fed daily	Body weight change		Pounds of FCM produced per pound of TDN consumed					
			Base[a] period	Test[b] period	Base period	Treated[c] as % of control	Test period	Treated as % of control	Test period corrected for body-weight changes	Treated as % of control
		(mg/1,000 lb. body wt.)	*(lb.)*			*(%)*	*(lb.)*	*(%)*	*(lb.)*	*(%)*
	81	0	9	133	1.37		1.15		1.34	
1	82	10	4	110	1.39	101	1.41	123	1.59	119
	84	0	39	38	.....		1.44		1.94	
2	83	10	40	18	.....		1.59	110	1.83	94
	86	0	27	91	1.35		0.68		0.76	
3	85	10	8	57	1.37	101	0.77	114	0.83	109
	40	0	8	138	1.32		1.03		1.17	
4	41	10	−27	96	1.65	125	1.10	107	1.19	102
	194	0	−32	138	1.98		1.33		1.47	
5	195	10	−14	148	2.12	107	1.51	114	1.66	113
Pooled av:	Control		8	108	1.52		1.09		1.34	
	Treated		2	86	1.66	109	1.25	115	1.42	106

[a] First to 56th day of lactation. All animals fed control ration during this period.

[b] The test period was the remainder of the lactation; the length for each pair, in weeks, was as follows: Pair 1—36, 2—9, 3—28, 4—34, and 5—36.

[c] Treated during base period refers to the animal of each pair that was scheduled to receive treatment.

the treated animal of each pair (except No. 2) was still more efficient than the control, even when correction for change in body weight was considered.

Brooks *et al. (2)* report that the coefficients of digestion of cellulose and protein were increased in yearling wethers that received 12 to 20 mg. of DES per day. Sykes *et al. (21)* reported an increase in digestibility of crude fiber and a decrease in digestibility of protein in dairy cows fed 10 mg. of DES daily. Whitehair *et al. (24)* and Clegg and Cole *(4)* have reported an increase in nitrogen retention by beef animals receiving DES implants.

Because there was greater total milk production by the treated cow in all twin pairs, there was a greater intake of TDN from concentrate by the treated cows. This was accompanied by a greater quantity of hay intake in only one case (Pair No. 4). Therefore, the increase in production cannot be attributed to a greater ad libitum intake of TDN because of increased hay consumption.

The reason for the greater efficiency by the treated cows used in this study is not known. It may have been owing to a more efficient digestion and/or utilization of the nutrients of the ration. However, it is possible that there was no change in efficiency of digestion or in utilization of the ration but that a hormonal stimulation of the pituitary increased production, giving more milk and greater efficiency per pound of TDN.

No noticeable undesirable side-effects were apparent in any of the animals fed DES. Milk samples were collected and analyzed for estrogenic activity. These data will be reported later.

Three of the five pairs of twins used in this study have been kept for study on the effects of DES in subsequent lactations. Although the subsequent lactations are as yet incomplete, results to date fail to show the uniformity of response attained during the first lactation.

SUMMARY

A study using five sets of identical-twin dairy cows was conducted to determine the effects on milk production of feeding DES during complete lactations.

Each cow treated produced more 4% FCM than did the control, although in one pair (No. 3) the difference in mean daily production was not significant at the 5% level.

The increased production was attributed to greater persistency. There was no marked difference in the fat or total solids of the milk between the treated and control animals.

The treated cows gained less weight during the test period than did the controls, in all but one pair. The cows receiving DES were approximately 6% more efficient in the production of 4% FCM than were the controls.

REFERENCES

(1) Bartlett, S., Folley, S. J., and Rowland, D. H. Estrogen and Possible Effects on Milk Secretion. *Nature*, **162**: 845. 1948.

(2) Brooks, C. C., Garner, G. B., Muhrer, M. E., and Pfander, W. H. Effect of Some Steroid Compounds on Ovine Rumen Function. *Science*, **120**: 455. 1954.

(3) Burroughs, W., Culbertson, C. C., Cheng, E., Hall, W. H., and Homeyer, P. The Influence of Oral Administration of Diethylstilbestrol to Beef Cattle. *J. Animal Sci.*, **14**: 1015. 1955.

(4) Clegg, M. T., and Cole, H. H. The Action of Stilbestrol on the Growth Response in Ruminants. *J. Animal Sci.*, **13**: 108. 1954.

(5) Day, F. T., and Hammon, J., Jr. Lactation in Heifers Induced by Estrogen Implants. *J. Agr. Sci.*, **35**: 150. 1945.

(6) Eaton, O. N., Simmons, V. L., Sykes, J. F., Wrenn, T. R., and Hall, S. R. A Study of the Effect of Stilbestrol-Induced Lactation on Dairy Goats. *J. Dairy Sci.*, **36**: 1089. 1953.

(7) Folley, S. J. The Effect of Estrogen Hormones on Lactation in the Cow. *J. Soc. Chem. Ind.*, **55**: 509. 1936.

(8) Folley, S. J. The Effect of Estrogenic Hormones on Lactation and on the Phosphatase of the Blood and Milk of the Lactating Cow. *Biochem. J.*, **30**: 2262. 1936.

(9) Folley, S. J., and Malpress, F. H. The Artificial Induction of Lactation in the Bovine by the Subcutaneous Implantation of Synthetic Estrogen Tablets. *J. Endocrinol.*, **4**: 1. 1944.

(10) Folley, S. J., and Malpress, F. H. Artificial Induction of Lactation in Bovines by Oral Administration of Synthetic Estrogens. *J. Endocrinol.*, **4**: 23. 1944.

(11) Folley, S. J., Scott Watson, H. M., and Bottomley, A. C. Initiation of Lactation in Nulliparous Heifers by Diethylstilbestrol. *J. Physiol.*, **100**: 7P. 1941.

(12) Folley, S. J., Scott Watson, H. M., and Bottomley, A. C. Experiment on the Chemical Enrichment of Cow's Milk by Administration of Diethylstilbestrol and Its Dipropionate. *J. Dairy Research*, **12**: 1. 1941.

(13) Foreman, C. F., and Porter, A. R. The Effect on Milk Production of Feeding Stilbestrol to Dairy Cows. *J. Animal Sci.*, **15**: 1286. 1956.

(14) Gaines, W. L., and Davidson, F. A. Ill. Agr. Expt. Sta., *Bull.* 245. 1923.

(15) Knott, J. C., Hodgson, R. E., and Ellington, E. V. Method of Measuring Pasture Yields with Dairy Cattle. Wash. Agr. Expt. Sta., *Bull.* 295. 1934.

(16) Lewis, A. A., and Turner, C. W. The Effect of Stilbestrol and Anterior Pituitary Extract upon Lactation in Goats. *J. Dairy Sci.*, **25**: 895. 1942.

(17) Mixner, J. P., Meites, J., and Turner, C. W. The Stimulation and Inhibition of Milk Secretion in Goats with Diethylstilbestrol. *J. Dairy Sci.*, **27**: 957. 1944.

(18) Perry, T. W., Beeson, W. M., Andrews, F. N., and Stob, M. The Effect of Oral Administration of Hormones on Growth Rate and Deposition in the Carcass of Fattening Steers. *J. Animal Sci.*, **14**: 329. 1955.

(19) Richardson, D., Mackintosh, D. L., Wheat, J. D., Menzies, C. S., and Cox, R. F. The Value of Stilbestrol in the Fattening Ration of Beef Steers. Kansas Agr. Expt. Sta., *Circ.* 335. 1956.

(20) Spielman, A., Ludwick, L. M., and Petersen, W. E. Effect of Diethylstilbestrol on Milk Secretion. *J. Dairy Sci.*, **24**: 499. 1941.

(21) Sykes, J. F., Wrenn, T. R., Kane, E. A., and Jacobson, W. C. Effect of Feeding Stilbestrol to Lactating Dairy Cows. *J. Dairy Sci.*, **39**: 925. 1956.

(22) Turner, C. W., Yamamoto, H., and Ruppert, H. L., Jr. The Experimental Induction of Growth of the Cow's Udder and the Initiation of Milk Secretion. *J. Dairy Sci.*, **39**: 1717. 1956.

(23) Turner, C. W., Yamamoto, H., and Ruppert, H. L., Jr. Endocrine Factors Influencing the Intensity of Milk Secretion. A. Estrogen, Thyroxine, and Growth Hormone. *J. Dairy Sci.*, **40**: 37. 1957.

(24) Whitehair, C. K., Gallup, W. D., and Bell, M. C. Effect of Stilbestrol on Ration Digestibility and on Calcium, Phosphorus, and Nitrogen Retention in Lambs. *J. Animal Sci.*, **12**: 331. 1953.

CHARACTERISTICS OF ORGANISMS CONTRIBUTING TO SPOILAGE IN COTTAGE CHEESE[1]

M. D. BONNER[2] AND L. G. HARMON
Dairy Department, Michigan State University, East Lansing

Effects of temperature, pH, sodium chloride, heat, and chemical germicides on the growth of 17 organisms isolated from spoiled cottage cheese were studied. None of the organisms grew at 3° C. for three days and 15 of 17 showed slight to profuse growth at 10° C. for seven days. All the organisms grew at pH 6.7 to 7.4. All except Torulopsis candida were retarded at pH 5.4 to 5.2 and lower. Fourteen of the 17 organisms grew in 5%, whereas only four grew in 7% sodium chloride. Pasteurizing at 61.7° C. for 30 min. destroyed all organisms. Sorbic acid was not effective in concentrations up to 0.25% at pH 5.2 to 6.7, but was inhibitory at pH 4.8 and 5.0. *Editor.*

Many investigators *(3, 4, 6, 7, 9, 10, 13, 15, 17, 19-21)* have reported organisms which grow at low temperatures. Most of these psychrophiles belong to the *Achromobacter, Alcaligenes, Flavobacterium,* or *Pseudomonas* genera. However, a few organisms causing spoilage in refrigerated food products are found in the *Aerobacter, Escherichia, Lactobacillus, Streptococcus,* and other genera.

Several workers *(6, 17, 20, 21)* have shown that psychrophilic species of the above genera failed to survive pasteurization at 143° F. for 30 min. Collins *(5)* showed that from 3 to 5 p.p.m. of chlorine at pH 6.0 was effective in destroying cultures of *Pseudomonas fragi, Pseudomonas viscosa, Alcaligenes metalcaligenes, Escherichia coli,* and *Aerobacter aerogenes.* Parker *et al. (19)* observed that hypochlorites have a more rapid germicidal action than quaternary ammonium compounds against *Pseudomonas fluorescens, Pseudomonas putrefaciens, P. fragi, P. viscosa,* and *A. metalcaligenes.* Johns *(14)* showed that iodophor compounds compared favorably with a quick-acting hypochlorite in destroying *Micrococcus pyogenes* var. *aureus, E. coli,* and *Pseudomonas aeruginosa.* Mueller *(18)* reported that 25 p.p.m. of iodine compared favorably with 100 p.p.m. of chlorine in killing *E. coli, Salmonella typhosa, M. pyogenes* var. *aureus,* and *P. aeruginosa,* in the presence of hard water and added organic matter.

EXPERIMENTAL PROCEDURE

Seventeen organisms isolated from spoiled cottage cheese and tentatively identified by Bonner *et al. (2)* were characterized as to *(a)* temperature limits of growth, *(b)* effect of pH on growth rate, *(c)* sodium chloride tolerance, *(d)* heat tolerance, *(e)* resistance to germicides, and *(f)* resistance to sorbic acid. The cultures were carried in trypticase soy broth and, except when indicated

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[1] Michigan Agricultural Experiment Station, Journal Article No. 2087.

[2] Present address: Krim-Ko Corp., 4830 S. Christiana Ave., Chicago 32, Illinois.

otherwise, the above characteristics were determined on 24-hr.-old cultures inoculated into trypticase soy broth. Growth of the organisms was measured by using a photometer, to compare the turbidities of inoculated broth and to duplicate uninoculated controls at the corresponding pH. Survival of the organisms was determined by plating the inoculated broth on suitable media.

Effect of temperature on growth rate. Loop inoculations of the cultures were placed in sterile tubes of broth and incubated at 3, 10, 20, 35, and 50° C. and were examined for growth after three and seven days of incubation.

Effect of pH on growth rate. The cultures were inoculated into broth adjusted to pH 4.0, 4.4, 4.6, 4.8, 5.0, 5.2, 5.4, 6.7, and 7.4, with lactic acid added prior to autoclaving. Inoculated tubes were incubated at 21° C. for three days and examined for growth.

Sodium chloride tolerance. The cultures were tested for ability to grow in broth solutions containing 1, 3, 5, 7, and 10% sodium chloride added to the medium before sterilization. Inoculated tubes were incubated at 21° C. for three days and examined for growth.

Heat tolerance. Twenty-four hour old skimmilk cultures were tested for survival from heating at 61.7° C. for 5, 10, 20, and 30 min. The cultures were heated in capillary tubes (1.5 by 90 mm.), cooled immediately, incubated at 21° C. for two days, and plated, using tryptone glucose yeast agar *(1)* to determine organism survival. The cultures were also tested in skimmilk at pH 6.7 and in whey at pH 4.55, for survival from heating at 48.9° C. for 15 min.—the approximate cooking temperature used in cottage cheese manufacture.

Resistance to germicides. The cultures were tested for survival in 10, 25, and 50 p.p.m. of hypochlorite, quaternary, and iodophor, when exposed for 1, 5, and 10 min. Stock solutions of hypochlorite and iodophor were standardized by titration with sodium thiosulfate *(16)* and the stock solution of quaternary was standardized by the Harper-Elliker method *(16)*. One hundred-milliliter portions containing 10, 25, and 50 p.p.m. of hypochlorite, quaternary, and iodophor were prepared by mixing the appropriate amount of the stock solution with sterile water at 15° C. immediately before testing each culture. One ml. of a broth culture of the organism was added to each 100 ml. of germicidal solution and the mixture well shaken. At intervals of 1, 5, and 10 min., loop inoculations were transferred into sterile tubes of broth, which were incubated at 21° C. for three days, then examined for growth.

Resistance to sorbic acid. The cultures were tested for survival in concentrations of 0.05, 0.10, and 0.25% sorbic acid at pH 4.8, 5.0, and 5.2 in trypticase soy broth. The broth solutions were made containing the desired sorbic acid concentrations and the pH then adjusted to the desired level with lactic acid prior to sterilization. The cultures were also tested at pH 6.7, 6.3, and 5.7, which resulted when sorbic acid concentrations of 0.05, 0.10, and 0.25%, respectively, were added to the broth with no attempt to control pH. The inoculated tubes were incubated at 21° C. for three days and the viability of the organisms determined by plating with tryptone glucose yeast agar *(1)*.

TABLE 1

Growth of various cottage cheese spoilage organisms when incubated in trypticase soy broth for three and seven days at various temperatures (three trials)

Microorganism	3° C.		10° C.		20° C.		35° C.		50° C.	
	3	7	3	7	3	7	3	7	3	7
	(days)									
Bacteria										
Achromobacter butyri	−	+	++	+++	+++	+++	−	+	−	−
Achromobacter eurydice	−	+	+	++	+++	+++	−	+	−	−
Alcaligenes metalcaligenes	−	+	+	++	++	++	−	+	−	−
Escherichia coli	−	+	++	+++	+++	+++	+++	+++	−	−
Escherichia freundii	−	−	++	+++	+++	+++	+++	+++	−	−
Micrococcus candidus	−	−	+	++	++	++	+	++	−	−
Micrococcus conglomeratus	−	−	−	−	+	++	+	++	−	−
Micrococcus flavus	−	+	−	++	+++	+++	+++	+++	−	−
Pseudomonas desmolyticum	−	−	++	+++	+++	+++	+++	+++	−	−
Pseudomonas fragi	−	+	+	+++	+++	+++	+	++	−	−
Pseudomonas fluorescens	−	+	+	++	+++	+++	−	+	−	−
Pseudomonas tralucida	−	−	++	+++	+++	+++	+++	+++	−	−
Yeasts:										
Rhotorula flava	−	−	−	+	+	++	−	−	−	−
Torula candida	−	−	−	++	+++	+++	−	−	−	−
Molds:										
Geotrichum candidum	−	−	+	++	++	++	+	++	−	−
Mucor plumbeus	−	++	+	++	++	++	−	+	−	−
Penicillium frequentans	−	−	−	−	+	++	−	−	−	−

Legend: − no growth, + slight growth, ++ moderate growth, +++ profuse growth.

RESULTS

Effect of temperature on growth rate. The data (Table 1) show the effect of temperature on the growth of various cheese spoilage organisms when grown in trypticase soy broth at pH 7.4.

None of the organisms tested exhibited visible growth in three days at 3° C. However, eight of the 17 organisms showed slight growth after seven days at this temperature. After three days at 10° C., five exhibited moderate growth and seven showed slight growth. Fifteen of the 17 cultures grew in seven days at 10° C.

All of the cultures grew at 20° C. and there was little difference in intensity of growth between three and seven days.

At 35° C., nine and 14 of the cultures grew in three and seven days, respectively. None of the 17 organisms grew at 50° C.

Effect of pH on growth rate. The effect of pH on the growth rate of 14 organisms causing spoilage in cottage cheese is shown (Figures 1 through 14). Nondispersible pellicle formation by the molds diminished the reliability of turbidity measurements; therefore, their growth rates were not included.

The various cultures reacted differently at the various pH levels, with the maximum growth rates occurring near neutrality. Growth of most of the organisms was materially reduced at pH 5.4, except *Torulopsis candida*, which grew well at all pH levels employed.

Sodium chloride tolerance. The effect of various concentrations of sodium chloride in trypticase soy broth at pH 7.4, on the growth of some organisms causing spoilage in cottage cheese, is shown (Table 2). All organisms grew in

TABLE 2

Growth of cottage cheese spoilage organisms in trypticase soy broth containing different concentrations of sodium chloride (three trials)

Microorganisms	Per cent NaCl (w/v)					
Bacteria:	0	1	3	5	7	10
A. butyri	+	+	+	+	−	−
A. eurydice	+	+	+	+	−	−
A. metalcaligenes	+	+	+	+	−	−
E. coli	+	+	+	+	+	−
E. freundii	+	+	+	+	−	−
M. candidus	+	+	−	−	−	−
M. conglomeratus	+	+	+	+	+	+
M. flavus	+	+	+	+	+	+
P. desmolyticum	+	+	+	+	−	−
P. fragi	+	+	+	+	−	−
P. fluorescens	+	+	+	+	−	−
P. tralucida	+	+	+	+	−	−
Yeasts:						
R. flava	+	+	+	−	−	−
T. candida	+	+	+	+	+	+
Molds:						
G. candidum	+	+	+	+	−	−
M. plumbeus	+	+	+	+	−	−
P. frequentans	+	+	+	−	−	−

Legend: + growth, − no growth.

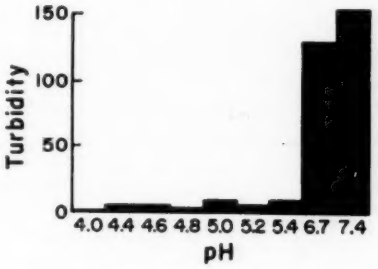

FIG. 1. *E. coli.*

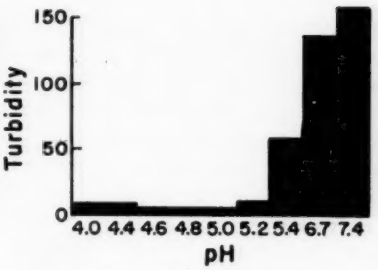

FIG. 2. *E. freundii.*

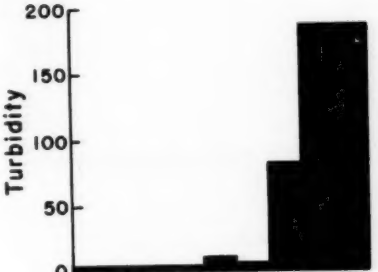

FIG. 3. *P. desmolyticum.*

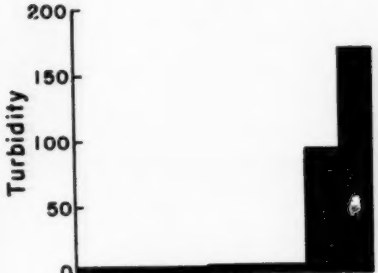

FIG. 4. *P. fluorescens.*

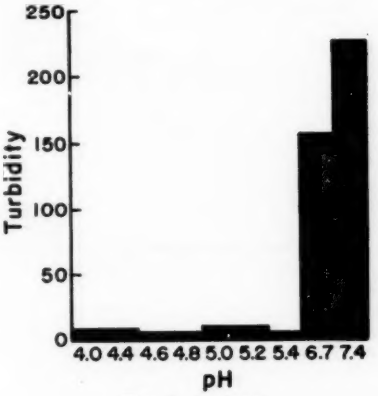

FIG. 5. *P. fragi.*

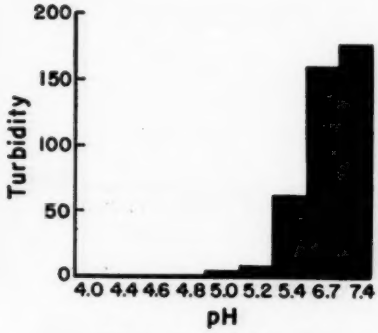

FIG. 6. *P. tralucida.*

1% sodium chloride, one failed to grow in 3%, and three failed to grow in 5%. Four of the cultures grew in 7% sodium chloride and three grew in 10% sodium chloride.

Heat tolerance. The data (Table 3) show the destruction of organisms causing spoilage in cottage cheese when held at 61.7° C. in skimmilk at pH 6.7.

Sixteen of the 17 cultures survived in skimmilk heated to 48.9° C. for 15 min. (Table 4), whereas only one of the organisms survived this temperature and holding time when heated in whey at pH 4.55.

Effect of germicides. (1) Chlorine. The data (Table 5) show the ability of spoilage organisms to survive complete destruction when exposed to 10, 25, and 50 p.p.m. of hypochlorite at pH 7.4 to 7.6 at 15° C. for 1, 5, and 10 min.

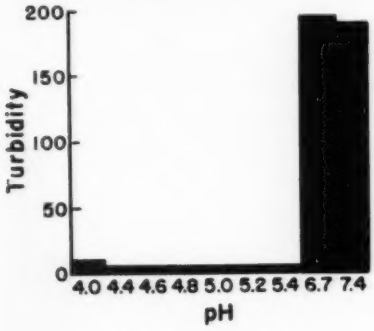

FIG. 7. *A. butyri.*

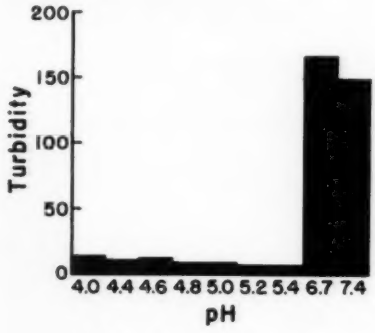

FIG. 8. *A. eurydice.*

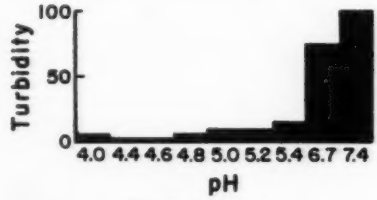

FIG. 9. *M. flavus.*

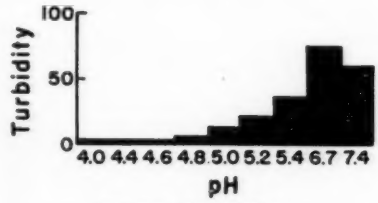

FIG. 10. *M. candidus.*

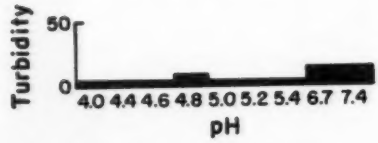

FIG. 11. *M. conglomeratus.*

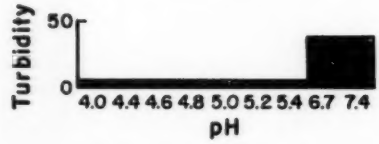

FIG. 12. *A. metalcaligenes.*

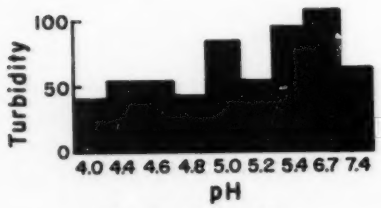

FIG. 13. *T. candida.*

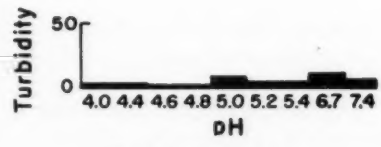

FIG. 14. *R. flava.*

TABLE 3
Destruction of cottage cheese spoilage organisms in skimmilk at 61.7° C. (five trials)

Microorganism	Minutes heated at 61.7° C.				
Bacteria:	0	5	10	20	30
A. butyri	+	+	−	−	−
A. eurydice	+	+	−	−	−
A. metalcaligenes	+	+	−[b]	−	−
E. coli	+	−	−	−	−
E. freundii	+	−	−	−	−
M. candidus	+	+[a]	−	−	−
M. conglomeratus	+	−	−	−	−
M. flavus	+	+[a]	−	−	−
P. desmolyticum	+	−[a]	−[b]	−	−
P. fragi	+	+	−	−	−
P. fluorescens	+	−	−	−	−
P. tralucida	+	+	+[a]	−	−
Yeasts:					
R. flava	+	−	−	−	−
T. candida	+	−	−	−	−
Molds:					
G. candidum	+	−	−	−	−
M. plumbeus	+	−	−	−	−
P. frequentans	+	−	−	−	−

Legend: + growth, − no growth.
[a] Growth in four of five trials.
[b] Growth in one of five trials.

(2) Quaternary. The data (Table 6) show the ineffectiveness of 10, 25, and 50 p.p.m. of quaternary, at pH 7.2 to 6.8 at 15° C. for 1, 5, and 10 min., in destroying the organisms used in this work.

Only eight of the 17 cultures tested were completely destroyed by 50 p.p.m. of quaternary with 10 min. of exposure. *(3) Iodophor.* The data (Table 7)

TABLE 4
Ability of cottage cheese spoilage organisms to survive at 48.9° C. for 15 min. in skimmilk at pH 6.7 and in whey at pH 4.55 (three trials)

Microorganism	Skimmilk	Whey
Bacteria:		
A. butyri	+	−
A. eurydice	+	−
A. metalcaligenes	+	−
E. coli	+	−
E. freundii	+	−
M. candidus	+	−
M. conglomeratus	−	−
M. flavus	+	−
P. desmolyticum	−	−
P. fragi	+	−
P. fluorescens	+	−
P. tralucida	+	−
Yeasts:		
R. flava	+	−
T. candida	+	−
Molds:		
G. candidum	+	+[a]
M. plumbeus	+	−
P. frequentans	+[a]	−

Legend: + growth, − no growth.
[a] Growth in two of three trials.

TABLE 5

Time required for complete destruction of cottage cheese spoilage organisms, when exposed to various concentrations of hypochlorite at pH 7.4 to 7.6 [a] at 15° C. (three trials)

Microorganism	Hypochlorite								
	10			25			50		
	(p.p.m.)								
	Exposure								
	(min.)								
	1	5	10	1	5	10	1	5	10
Bacteria:									
A. butyri	+	+	+	+	+	+	−[b]	−	−
A. eurydice	+	+	−	+	+	−	−	−	−
A. metalcaligenes	+	+	+	+	−[b]	−	−	−	−
E. coli	+	+	+	+	+	+	−	−	−
E. freundii	+	+	+	+	+	−[b]	−	−	−
M. candidus	+	−[b]	−	−	−	−	−	−	−
M. conglomeratus	+	+	+	+	+	+	−	−	−
M. flavus	+	+	+	+	+	+	+	−	−
P. desmolyticum	+	+	+	+	+	−	−	−	−
P. fluorescens	+	+	+	+	+	−	−	−	−
P. fragi	+	+	+	+	+	−[b]	−	−	−
P. tralucida	+	+	+	+	+	−	−	−	−
Yeasts:									
R. flava	−	−	−	−	−	−	−	−	−
T. candida	+	+	+	+	+	+	+[c]	−	−
Molds:									
G. candidum	+	+	+	+	+	−	−	−	−
M. plumbeus	+	+	+	+	+	+	+[c]	−	−
P. frequentans	+	+	+	+	+	+	−	−	−

Legend: + growth, − no growth.

[a] Solutions prepared according to manufacturer's recommendation had a pH of from 7.4 to 7.6 at 15° C.

[b] Growth in one of three trials.

[c] Growth in two of three trials.

show the ability of the organisms to survive complete destruction when exposed to 10, 25, and 50 p.p.m. of iodophor at pH of 5.8 to 5.1 for 1, 5, and 10 min. Fifty p.p.m. of iodophor, with 1 min. of exposure, completely destroyed ten of the 17 cultures. Increased time did not significantly increase germicidal efficiency.

Effect of sorbic acid. The effect of various concentrations of sorbic acid at different pH levels, on the viability of the organisms in trypticase soy broth, is shown (Table 8).

Only a small number of the organisms tested was destroyed by 0.05, 0.10, and 0.25% sorbic acid at pH 5.2 or above, but at pH 5.0 and 4.8 the viability of the cultures decreased considerably as the sorbic acid content increased from 0.05 to 0.25%.

Data not included *(11)* show objectionable flavors in cottage cheese washed with waters containing more than 10 p.p.m. of iodophor or 0.10% sorbic acid.

DISCUSSION

The data presented show that many organisms identified with spoilage in cottage cheese are able to grow vigorously at from 45 to 50° F. (7 to 10° C.),

TABLE 6

Viability of spoilage organisms after exposure to different concentrations of quaternary at pH 7.2 to 6.8 [a] at 15° C. for various times (three trials)

Microorganism	Quaternary								
	(p.p.m.)								
	10			25			50		
	Exposure								
	(min.)								
	1	5	10	1	5	10	1	5	10
Bacteria:									
A. butyri	+	+	+	+	+	+	+	+	+
A. eurydice	+	+	+	+	+	+	+	+	+
A. metalcaligenes	+	+	+	+	+[c]	+	+	+	+[b]
E. coli	+	+	+	+	+	+	+	+	−
E. freundii	+	+	+	+	+	+	+	+	−
M. candidus	+	+	+	−	−	−	−	−	−
M. conglomeratus	−	−	−	−	−	−	−	−	−
M. flavus	+[c]	−	−	−	−	−	−	−	−
P. desmolyticum	+	+	+	+	+	+	+	+	+
P. fluorescens	+	+	+	+	+	+	+	+	+
P. fragi	+	+	+	+	+	+	+	+	+
P. tralucida	+	+	+	+	+	+	+	+	+
Yeasts:									
R. flava	−[b]	−[b]	−	−	−	−	−	−	−
T. candida	+	+	+	+	+	+[b]	−	−	−
Molds:									
G. candidum	+	+	+	+	+	+	+[c]	−	−
M. plumbeus	+[c]	+	+	+	+	+	+	+	+
P. frequentans	+	+	+	+	+	+	+[c]	−	−

Legend: + growth, − no growth.

[a] Solutions prepared according to manufacturer's recommendations had a pH of 7.2 to 6.8 at 15° C.

[b] Growth in one of three trials.

[c] Growth in two of three trials.

temperatures commonly used in handling and marketing cottage cheese and other dairy products *(12)*. The need for lower handling temperatures is indicated by the data (Table 1), which show no growth of the common psychrophilic spoilage organisms at 3° C. (37° F.) after three days and only slight growth after seven days; whereas, at 10° C. (50° F.) the growth was much greater.

The data (Figures 1 to 14 inclusive) substantiate the benefit of low pH, previously reported by other authors *(4, 7, 19)*, in controlling growth of psychrophilic organisms in cottage cheese, and suggest the desirability of considering processing procedures which might reduce the pH of the creamed cheese without detracting from the bland flavor preferred by most consumers.

Use of sodium chloride apparently offers little protection against spoilage organisms in cottage cheese. It is impractical to use sodium chloride concentrations above 5%, in storing curd or in creaming mixtures. Fourteen of the 17 organisms tested, including all of the more common spoilage organisms, grew in trypticase soy broth containing 5% sodium chloride.

TABLE 5

Time required for complete destruction of cottage cheese spoilage organisms, when exposed to various concentrations of hypochlorite at pH 7.4 to 7.6[a] at 15° C. (three trials)

Microorganism	Hypochlorite								
	10			25			50		
	(p.p.m.)								
	Exposure								
	(min.)								
	1	5	10	1	5	10	1	5	10
Bacteria:									
A. butyri	+	+	+	+	+	+	−[b]	−	−
A. eurydice	+	+	−	+	+	−	−	−	−
A. metalcaligenes	+	+	+	+	−[b]	−	−	−	−
E. coli	+	+	+	+	+	+	−	−	−
E. freundii	+	+	+	+	+	−[b]	−	−	−
M. candidus	+	−[b]	−	−	−	−	−	−	−
M. conglomeratus	+	+	+	+	+	+	−	−	−
M. flavus	+	+	+	+	+	+	+	−	−
P. desmolyticum	+	+	+	+	+	−	−	−	−
P. fluorescens	+	+	+	+	+	−	−	−	−
P. fragi	+	+	+	+	+	−[b]	−	−	−
P. tralucida	+	+	+	+	+	−	−	−	−
Yeasts:									
R. flava	−	−	−	−	−	−	−	−	−
T. candida	+	+	+	+	+	+	+[c]	−	−
Molds:									
G. candidum	+	+	+	+	+	−	−	−	−
M. plumbeus	+	+	+	+	+	+	+[c]	−	−
P. frequentans	+	+	+	+	+	+	−	−	−

Legend: + growth, − no growth.

[a] Solutions prepared according to manufacturer's recommendation had a pH of from 7.4 to 7.6 at 15° C.

[b] Growth in one of three trials.

[c] Growth in two of three trials.

show the ability of the organisms to survive complete destruction when exposed to 10, 25, and 50 p.p.m. of iodophor at pH of 5.8 to 5.1 for 1, 5, and 10 min. Fifty p.p.m. of iodophor, with 1 min. of exposure, completely destroyed ten of the 17 cultures. Increased time did not significantly increase germicidal efficiency.

Effect of sorbic acid. The effect of various concentrations of sorbic acid at different pH levels, on the viability of the organisms in trypticase soy broth, is shown (Table 8).

Only a small number of the organisms tested was destroyed by 0.05, 0.10, and 0.25% sorbic acid at pH 5.2 or above, but at pH 5.0 and 4.8 the viability of the cultures decreased considerably as the sorbic acid content increased from 0.05 to 0.25%.

Data not included *(11)* show objectionable flavors in cottage cheese washed with waters containing more than 10 p.p.m. of iodophor or 0.10% sorbic acid.

DISCUSSION

The data presented show that many organisms identified with spoilage in cottage cheese are able to grow vigorously at from 45 to 50° F. (7 to 10° C.),

TABLE 6

Viability of spoilage organisms after exposure to different concentrations of quaternary at pH 7.2 to 6.8 [a] *at 15° C. for various times (three trials)*

Microorganism	Quaternary								
	(p.p.m.)								
	10			25			50		
	Exposure								
	(min.)								
	1	5	10	1	5	10	1	5	10
Bacteria:									
A. butyri	+	+	+	+	+	+	+	+	+
A. eurydice	+	+	+	+	+	+	+	+	+
A. metalcaligenes	+	+	+	+	+[c]	+	+	+	+[b]
E. coli	+	+	+	+	+	+	+	+	−
E. freundii	+	+	+	+	+	+	+	+	−
M. candidus	+	+	+	−	−	−	−	−	−
M. conglomeratus	−	−	−	−	−	−	−	−	−
M. flavus	+[c]	−	−	−	−	−	−	−	−
P. desmolyticum	+	+	+	+	+	+	+	+	+
P. fluorescens	+	+	+	+	+	+	+	+	+
P. fragi	+	+	+	+	+	+	+	+	+
P. tralucida	+	+	+	+	+	+	+	+	+
Yeasts:									
R. flava	−[b]	−[b]	−	−	−	−	−	−	−
T. candida	+	+	+	+	+	+[b]	−	−	−
Molds:									
G. candidum	+	+	+	+	+	+	+[c]	−	−
M. plumbeus	+[c]	+	+	+	+	+	+	+	+
P. frequentans	+	+	+	+	+	+	+[c]	−	−

Legend: + growth, − no growth.

[a] Solutions prepared according to manufacturer's recommendations had a pH of 7.2 to 6.8 at 15° C.

[b] Growth in one of three trials.

[c] Growth in two of three trials.

temperatures commonly used in handling and marketing cottage cheese and other dairy products *(12)*. The need for lower handling temperatures is indicated by the data (Table 1), which show no growth of the common psychrophilic spoilage organisms at 3° C. (37° F.) after three days and only slight growth after seven days; whereas, at 10° C. (50° F.) the growth was much greater.

The data (Figures 1 to 14 inclusive) substantiate the benefit of low pH, previously reported by other authors *(4, 7, 19)*, in controlling growth of psychrophilic organisms in cottage cheese, and suggest the desirability of considering processing procedures which might reduce the pH of the creamed cheese without detracting from the bland flavor preferred by most consumers.

Use of sodium chloride apparently offers little protection against spoilage organisms in cottage cheese. It is impractical to use sodium chloride concentrations above 5%, in storing curd or in creaming mixtures. Fourteen of the 17 organisms tested, including all of the more common spoilage organisms, grew in trypticase soy broth containing 5% sodium chloride.

None of the organisms tested survived 61.7° C. for 20 min. These results substantiate reports of numerous other authors *(6, 17, 20, 21)*, who found that proper pasteurization destroys the majority of organisms causing spoilage in cottage cheese. Only one of the 17 cultures survived when heated to 48.9° C. for 15 min. in whey at pH 4.55. The curd particles may provide some protection to the organisms, but the temperature and pH of the whey and curd are nearly the same during cooking. It is a reasonable assumption that the cooking process destroys most of the organisms causing spoilage and that postcooking contamination is an important factor in keeping-quality.

With the chlorine and iodophor compounds, concentration appeared to be more important than reaction time in destroying organisms, under the conditions used in this work. The organisms most commonly associated with cheese spoilage were recovered after exposure to 25 p.p.m. of iodophor for 10 min., but were completely destroyed by 50 p.p.m. for 1 min. The lower pH (5.1) in the latter

TABLE 7

Viability of spoilage organisms after exposure to different concentrations of idophor at pH 5.8 to 5.1 [a] at 15° C. for various times (three trials)

Microorganism	Iodophor								
	(p.p.m.)								
	10			25			50		
	Exposure								
	(min.)								
	1	5	10	1	5	10	1	5	10
Bacteria:									
A. butyri	+	+	+	+	+	+	−	−	−
A. eurydice	+	+	+	+	+	+	+	+[c]	+
A. metalcaligenes	+	+	+	+	+	+	−	−	−
E. coli	+	+	+	+	+	+	−	−	−
E. freundii	+	+	+	+	+	+[c]	−	−	−
M. candidus	+	+	+	+	+	+	+[b]	−	−
M. conglomeratus	+	+	+	+	+	+	−[b]	−	−
M. flavus	+	+	+	+	+	+	−	−	−
P. desmolyticum	+	+	+	+	+	+	−	−	−[b]
P. fluorescens	+	+	+	+	+	+	−	−[b]	−
P. fragi	+	+	+	+	+	+	−	−	−
P. tralucida	+	+	+	+	+	+	+	+[c]	+
Yeasts:									
R. flava	+	+	+	−	−[b]	−	−	−	−
T. candida	+	+	+	+	+	+	−	−	−
Molds:									
G. candidum	+	+	+	+	+	+	+	+	+
M. plumbeus	+	+	+	+	+	+	+	+	+
P. frequentans	+	+	+	+	+	+	+	+	+

Legend: + growth, − no growth.

[a] Solutions prepared according to manufacturer's recommendations had a pH of from 5.8 to 5.1 at 15° C.

[b] Growth in one of three trials.

[c] Growth in two of three trials.

TABLE 8

Viability[a] of spoilage organisms after exposure to differeent concentrations of sorbic acid at various pH levels (two trials)

Microorganism	pH of medium															
	7.3	6.7	6.3	5.7	5.2				5.0				4.8			
	(% sorbic acid w/v)															
	0	.05	.10	.25	0	.05	.10	.25	0	.05	.10	.25	0	.05	.10	.25
Bacteria:																
A. butyri	+++	+++	+++	+++	+++	+++	+++	++	+++	+	[b]	−	++	−	−	−
A. eurydice	+++	+++	+++	+++	+++	+++	+++	[b]	+	[b]	−	−	+	−	−	−
A. metalcaligenes	+++	+++	+++	+++	+	+	[b]	[b]	[b]	[b]	[b]	−	[b]	−	−	−
E. coli	+++	+++	+++	+++	+++	+++	+++	[b]	+++	++	[b]	−	+++	+	[b]	−
E. freundii	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	−	+++	+	[b]	−
M. candidus	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	+++	+++	+++	+
M. conglomeratus	+++	+++	+++	+	+	+	++	+	+	+	[b]	−	+	[b]	−	−
M. flavus	+++	+++	+++	+++	++	++	++	+	++	+	+	+	+++	+	+	+
P. desmolyticum	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	−	+++	++	[b]	−
P. fluorescens	+++	+++	+++	+++	[b]	−	−	−	−	−	[b]	−	−	−	−	−
P. fragi	+++	+++	+++	+++	++	+	+	+	+	[b]	[b]	−	+	−	−	−
P. tralucida	+++	+++	+++	+++	+++	+++	+++	+++	+++	++	[b]	−	+++	+++	[b]	−
Yeasts:																
R. flava	+++	+++	+	[b]	+	--	−	−	+	−	−	−	[b]	−	−	−
T. candida	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	[b]	+++	+++	+++	−
Molds:																
G. candidum	+++	+++	+++	+++	+++	+++	+++	+	+++	+++	+++	[b]	+++	+++	[b]	−
M. plumbeus	+++	+++	+++	+++	+++	+++	+++	+	+++	+	[b]	[b]	+++	[b]	[b]	−
P. frequentans	+++	+++	+++	+++	+++	+++	+++	+	+++	++	+	[b]	+++	+++	+	−

[a] Legend: — no growth, + slight growth, ++ moderate growth, +++ profuse growth.
[b] One positive and one negative growth on duplicate trials.

concentration probably contributed to efficiency of destruction. The iodophor did not destroy the molds at the concentrations and time exposure used.

The data (Tables 5 and 7) suggest that the commonly recommended procedure of adding 10 to 15 p.p.m. of hypochlorite, or 7.5 p.p.m. of iodophor, to dairy-plant water supplies may not be effective. Some conditions of this experiment may have protected the organisms from complete destruction by germicidal agents. After subjection to the germicides, the cultures were incubated in trypticase soy broth at 21° C. for three days, during which time some temporarily damaged cells may have recovered.

The germicidal efficiencies were determined in water at 15° C. and pH 7.4, which contained some organic matter (trypticase soy broth) introduced with the inoculation. However, the above conditions approximate those prevailing in many plants, where water supplies are not acidified prior to the addition of the germicidal agent and there is ample time for recovery of organisms subjected to sublethal treatment. Comparison of these results with those of Collins *(5)*, in which destruction of washed cells of several spoilage organisms was accomplished in less than 1 min. in 3 p.p.m. of chlorine, in water at 4.4° C. and pH 6.0, emphasizes the need for acidification of water supplies before chlorination.

The quaternary was ineffective against the gram-negative organisms, which include most of the psychrophiles. These results concur with those of Elliker *(8)*.

Concentrations of sorbic acid used in this work were not effective in destroying the organisms when the pH was not reduced. However, sorbic acid is an inhibitor rather than a germicide, and the data (Table 8) may not reflect the true inhibitory capacity. The data show the viability of the organisms, after exposure to sorbic acid, when plated on tryptone glucose yeast agar. The data on sorbic acid, like the data on the germicides, are an indication of survival of the organisms, rather than a measurement of effectiveness of inhibition.

SUMMARY AND CONCLUSIONS

The effect of incubation temperature, pH, sodium chloride, heat, chlorine, quaternary, iodophor, and sorbic acid on the growth of 17 organisms isolated from spoiled cottage cheese was determined.

None of the organisms showed growth after incubation for three days at 3° C. Fifteen of the 17 organisms showed growth ranging from slight to profuse, after incubation for seven days at 10° C.

Most of the organisms thrived in the pH range of 6.7 to 7.4 and, with the exception of *Torulopsis candida*, growth was retarded at pH 5.4 to 5.2 and below. Fourteen of the 17 organisms grew in 5% sodium chloride, whereas only four grew in 7% sodium chloride.

Pasteurization at 61.7° C. for 30 min. destroyed all organisms tested. Sixteen of the cultures survived 48.9° C. for 15 min. in skimmilk; whereas, only one survived the above temperature and holding time in whey at pH 4.55.

Hypochlorite was the most effective germicide employed, and the iodophor and the quaternary compounds were second and third most effective. The concen-

trations of sorbic acid used in this work were not effective in completely destroying the organisms, when the pH was not reduced.

REFERENCES

(1) American Public Health Association. *Standard Methods for the Examination of Dairy Products.* 10th ed. New York. 1953.

(2) Bonner, M. D., Harmon, L. G., and Smith, C. K. Defects Produced by Spoilage Organisms in Cottage Cheese Sterilized by Cathode Rays. *J. Dairy Sci.*, **40**: 1360. 1957.

(3) Burgwald, L. G., and Josephson, D. V. The Effect of Refrigerated Storage on the Keeping Qualities of Pasteurized Milk. *J. Dairy Sci.*, **30**: 371. 1947.

(4) Collins, E. B. Factors Involved in the Control of Gelatinous Curd Defects of Cottage Cheese. I. Storage Temperature and pH. *J. Milk and Food Technol.*, **18**: 169. 1955.

(5) Collins, E. B. Factors Involved in the Gelatinous Curd Defects of Cottage Cheese. II. Influence of pH and Temperature on the Bactericidal Efficiency of Chlorine. *J. Milk and Food Technol.*, **18**: 189. 1955.

(6) Dahlberg, A. C. The Relationship of the Growth of All Bacteria and Coliform Bacteria in Pasteurized Milk Held at Refrigerator Temperatures. *J. Dairy Sci.*, **29**: 651. 1946.

(7) Davis, P. A., and Babel, F. J. Slime Formation on Cottage Cheese. *J. Dairy Sci.*, **37**: 176. 1954.

(8) Elliker, P. R. The Application of Quaternary Ammonium Compounds in Dairy Sanitation. *J. Milk and Food Technol.*, **13**: 156. 1952.

(9) Erdman, I. E., and Thornton, H. R. Psychrophilic Bacteria in Edmonton Milk and Cream. II. Kinds. *Can. J. Technol.*, **29**: 238. 1951.

(10) Greene, V. W., and Jezeski, J. J. Influence of Temperature on the Development of Several Psychrophilic Bacteria of Dairy Origin. *Appl. Microbiol.*, **2**: 110. 1954.

(11) Harmon, L. G., Bonner, M. D., and Hedrick, T. I. Unpublished data. Mich. Agr. Expt. Sta., East Lansing.

(12) Harmon, L. G., Trout, G. M., and Bonner, M. D. A Market Survey of Cottage Cheese. I. Some Characteristics Influencing Consumer Acceptance and Shelf-Life. Mich. Agr. Expt. Sta., *Quart. Bull.*, **38**: 146. 1955.

(13) Jezeski, J. J., and Macy, H. Cryophilic Organisms in Water and Butter. *J. Dairy Sci.*, **29**: 439. 1946.

(14) Johns, C. K. Iodophors as Sanitizing Agents. *Can. J. Technol.*, **32**: 71. 1954.

(15) Kennedy, L., and Weiser, H. Some Observations on Bacteria Isolated from Milk that Grow Within a Psychrophilic Temperature Range. *J. Milk and Food Technol.*, **13**: 353. 1950.

(16) Klenzade Products Co. *Klenzade Dairy Sanitation Handbook.* Beloit, Wis. 1954.

(17) Lawton, W. C., and Nelson, F. E. The Effect of Storage Temperatures on the Growth of Psychrophilic Organisms in Sterile and Laboratory Pasteurized Skimmilks. *J. Dairy Sci.*, **37**: 1164. 1954.

(18) Mueller, W. S. Bactericidal Effectiveness of Iodophor Detergent-Sanitizers. *J. Milk and Food Technol.*, **18**: 144. 1955.

(19) Parker, R. B., Caldwell, A. L., and Elliker, P. R. Psychrophilic Bacteria—a Sanitation Problem. *J. Milk and Food Technol.*, **16**: 136. 1953.

(20) Thomas, S. E., Thomas, B. F., and Ellison, D. Milk Bacteria Which Grow at Refrigerator Temperatures. *Dairy Inds.*, **14**: 921. 1947.

(21) Watrous, G. H., Jr., Doan, F. J., and Josephson, D. V. Some Bacteriological Studies on Refrigerated Milk and Cream. Penn. State Coll. Agr. Expt. Sta., *Bull.* 551. 1952.

FERTILITY OF BULLS FED LARGE AMOUNTS OF GRASS SILAGE FOR ONE AND TWO YEARS[1]

R. J. FLIPSE AND J. O. ALMQUIST
Dairy Breeding Research Center, Department of Dairy Science, The Pennsylvania State University, University Park

Effects on the fertility of seven pairs of bulls fed liberal amounts of grass silage and hay, and bulls receiving a control ration of hay and concentrates, were compared for two years. There were 30,845 first services for the silage-fed bulls and 36,025 for the controls, and the 180-day nonreturn rates were 66.2 and 66.6%, respectively. The nonreturn rates were essentially the same for 18 pairs of bulls for one year. Feeding grass silage liberally in a high-roughage ration reduced costs substantially. *Editor.*

Investigations conducted during the past few years *(1, 2, 4)* have indicated that grass silage can be fed to dairy bulls in amounts far above the previously recommended level of 15 lb. daily. These trials were indicative of the value of grass silage, but the fact that results were evaluated by laboratory examination of semen *(1)*, or fertility trials of unspecified scope *(2, 4)*, has undoubtedly limited the general acceptance of grass silage as a feed for bulls.

The field trial reported herein was undertaken to obtain extensive data on the effect of an all-roughage ration, including liberal use of grass silage, on the fertility of bulls maintained on this ration for a 2-yr. period.

EXPERIMENTAL PROCEDURES

A total of 42 bulls at the Western Pennsylvania Artificial Breeding Cooperative was paired with respect to breed, age, body weight, and fertility. One bull of each pair was randomly assigned to the experimental (silage) group and his pair-mate to the control group. While 21 pairings were made initially, three pairs were disrupted during the early weeks of the experiment (actinomycosis, poor type and low production of daughters, and failure of rumination associated with old age). Eighteen pairs completed the first year of the trial and seven pairs completed the 2-yr. experiment. In no instance was there an association between the high level of silage feeding and the cause for removal of a bull from the experiment. Of the 11 pairs failing to complete the second year of the trial, four pairs were disrupted due to one member being retired to await proof, three pairs because of low production and/or poor type of daughters, two owing to accidents, one because of a tumor in the thoracic cavity, and one as a result of poor semen quality (a control bull). The seven pairs completing the experiment, and data pertinent to the pairings, are shown (Table 1), and are representative of all the animals involved. Of the 18 pairs included during the first year, six were Holsteins, six Guernseys, three Jerseys, and three Herefords.

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TABLE 1

Growth and fertility data on seven pairs of bulls completing 2-yr. experiment

Bull	Group	Age at start of experiment	Body weight		Paunch girth		Pre-exptl. fertility (April–Sept., 1953		Exptl. fertility (Oct., 1953–Sept., 1955)	
			Initial	Final	Initial	Final	1st serv.	180-day N.R.	1st serv.	180-day N.R.
		(Yr.)	*(lb.)*		*(in.)*		*(No.)*	*(%)*	*(No.)*	*(%)*
H14	S	6.9	2,120	2,054	104	104	297	69.0	2,856	65.6
H13	C	6.5	2,400	2,394	117	117	625	70.6	8,761	68.7
G4	S	8.6	1,494	1,540	93	99	1,698	71.3	9,103	69.8
G3	C	9.4	1,528	1,614	96	104	1,624	67.5	10,432	65.8
G11	S	2.1	1,406	1,616	93	96	1,209	65.9	4,030	66.2
G12	C	1.7	1,244	1,822	90	103	1,595	66.5	4,205	64.5
G13	S	1.6	1,080	1,656	88	99	554	68.4	4,481	64.5
G14	C	1.4	980	1,752	84	102	155	68.4	3,931	67.8
J8	S	2.0	1,026	1,344	84	95	425	66.1	2,471	64.1
J7	C	2.4	1,124	1,284	85	91	478	66.5	1,373	69.3
W3	S	8.7	1,830	1,798	99	101	834	66.4	4,398	63.8
W4	C	7.7	1,728	1,704	97	99	851	64.4	3,824	64.5
W6	S	3.1	1,442	1,644	88	98	786	65.5	3,506	69.6
W5	C	3.3	1,464	1,582	96	99	753	62.7	3,499	65.3
Totals and means (weighted by bulls)										
	Silage		1,485	1,665	92.8	98.9	5,803	67.5	30,845	66.2
	Control		1,495	1,736	95.0	102.1	6,081	66.7	36,025	66.6
Summary—18 pairs for first year only:										
	Silage		1,714	1,722	98.8	101.2	18,323	66.5	40,833	64.9
	Control		1,703	1,762	98.6	102.1	18,759	68.2	43,839	65.3

Ages at the start of the experiment ranged from 1.4 to 10.9 yr.; the mean age was 5.8 yr.

Experimental bulls received approximately 3 lb. of grass silage per 100 lb. of body weight according to the following schedule:

Body weight (lb.)	*Pounds silage fed daily*
1,199 or less	30
1,200 to 1,499	40
1,500 to 1,799	50
1,800 to 2,099	60
2,100 or more	70

In addition to the silage, each bull received approximately 7 lb. of good-quality mixed hay daily. Bulls in the control group received the same hay as those in the experimental group, plus a concentrate ration. Hay was fed at a level of 14 to 18 lb. daily and sufficient concentrate to provide the recommended allowance for total digestible nutrients *(3)*.

Silage feeding was commenced at low levels in mid-September, 1953, and the amount was increased steadily until the specified levels were being fed when the experiment started on October 1, 1953. Because of inadequate silo capacity, no silage was available for 22 days in June, 1954, and for ten days in June, 1955. Aside from these two short periods, concentrates were not fed to the experimental

group during the trial. The only exception to this was J8, a 2-yr.-old Jersey bull that refused to eat sufficient silage to maintain the desired rate of growth. This bull received a supplement of 2 lb. of soybean oil meal daily during the last 17 mo. of the trial.

The species of forage harvested for silage was predominantly an alfalfa–brome grass mixture, although small amounts of clover, wheat, timothy, and rye were included. Sodium metabisulfite was used as a preservative. Silage samples were collected at monthly intervals and analyzed for moisture and protein content. The moisture content averaged 67.6%; crude protein varied considerably, depending upon the species being used, but averaged 4.7%.

RESULTS AND DISCUSSION

Of the 21 pairings made initially, 18 pairs completed the first year of the experiment and seven pairs completed the entire 2-yr. period. The 180-day nonreturns to first services for pairs completing the 2-yr. period are presented (Table 1). With over 30,000 first services per group, no differences in fertility were observed, using "Student's" *t*-test. No time trends which could be associated with the rations fed were noted. Laboratory semen-quality determinations (Table 2) likewise revealed no differences between the groups.

Although only seven pairs completed the 2-yr. period intact, a total of 15 silage bulls and ten control bulls completed the 2-yr. trial. The 180-day nonreturn rate for the 15 silage bulls was 66.0% (76,983 first services) and for the ten control bulls, 67.0% (57,090 first services).

Initial and final body weight and paunch girth measurements are recorded (Table 1). The mean differences were small, and could be accounted for by differences in response by young growing bulls. Some of the young growing

TABLE 2

Semen quantity, quality, and collection data on seven pairs of bulls completing 2-yr. experiment

Group	Quarter								Mean
	I[a]	II	III	IV	V	VI	VII	VIII	
	Semen volume (ml.)								
Silage	5.5	5.5	5.8	6.0	6.1	5.8	6.3	6.3	5.9
Control	5.7	6.0	6.2	5.9	6.2	6.0	6.4	6.5	6.1
	Initial motility (%)								
Silage	64	64	64	65	64	63	64	62	64
Control	63	65	65	64	64	64	65	63	64
	Concentration ($\times 10^9$ per ml.)								
Silage	1.44	1.61	1.49	1.43	1.34	1.39	1.32	1.32	1.42
Control	1.18	1.35	1.43	1.42	1.47	1.45	1.35	1.30	1.37
	No. of collection days								
Silage	11.7	14.0	16.3	18.0	13.0	13.6	14.7	15.0	14.5
Control	10.7	14.7	15.0	12.9	14.6	13.9	14.7	14.9	13.9
	No. of ejaculates used								
Silage	16.6	16.4	19.6	21.3	16.6	18.9	19.9	20.4	18.7
Control	14.0	17.6	17.6	16.1	17.4	18.0	17.7	18.6	17.1

[a] Quarter I = October, November, and December, 1953.

bulls receiving silage failed to gain weight as rapidly as did their pair-mates. After the first 4 mo., the silage allotment to such bulls was increased by 10 lb.; a month later, a few bulls received an additional increase of 10 lb. daily. Subsequently, their growth kept pace with that of pair-mates that were on the control ration.

Although the rate of silage feeding in this study was only 3 lb. daily per 100 lb. of body weight, compared to 4 lb. in our previous study *(1)*, the results with regard to body measurements, sexual response of animals, and quality of semen produced were similar to those previously reported. In addition, sufficient fertility data have been obtained to show that fertility was not influenced when this rate of silage feeding was continued over a 2-yr. period.

One of the most attractive features of the high-silage feeding program for bulls is its economy. Shortly after the completion of this experiment, in September, 1955, the breeding organization involved placed all bulls on a high-roughage regimen, in which approximately 47% of the TDN came from grass silage, 30% from hay, and 23% from concentrates. On this system of feeding, the actual feed cost during 1956 was $142 per bull. Using consumption figures for 1952, the last full year in which the conventional hay-concentrate regimen was used, and prices paid in 1956 ($76, $25, and $10 per ton for concentrates, hay, and grass silage, respectively), the comparable cost on the conventional system was $200 per bull per year. Thus, a saving of 29% on feed costs was effected by the change to the high-roughage system.

SUMMARY

Seven pairs of bulls were maintained for 2 yr. on an experiment comparing a ration of grass silage (fed at daily rate of 3 lb. per 100 lb. of body weight) and hay, with a control ration of hay and concentrates. Over the 2-yr. period, there were 30,845 first services to the silage-fed bulls and 36,025 first services to the control bulls. The 180-day nonreturn rate was 66.2 and 66.6% for the silage and control groups, respectively. Eighteen pairs of bulls similarly treated for a 1-yr. period had 40,833 and 43,839 first services, and 180-day nonreturn rates of 64.9 and 65.3%, for the silage and control groups, respectively.

The all-roughage ration maintained bulls in good condition throughout the 2-yr. period, and semen quality was not affected. Liberal use of grass silage in a high-roughage feeding program at the breeding organization resulted in a considerable reduction in feed cost.

ACKNOWLEDGMENT

The authors wish to express their appreciation to G. W. Thompson and employees of the Western Pennsylvania Artificial Breeding Cooperative, Clarion, whose cooperation made this study possible.

REFERENCES

(1) Flipse, R. J., Thacker, D. L., and Almquist, J. O. Effects of Feeding Large Amounts of Grass Silage to Dairy Bulls on Feed Utilization, Body Measurements, and Semen Quality. *J. Dairy Sci.*, **35**: 949. 1952.

(2) HENDERSON, B. W., JR., AND NORTON, C. L. Grass Silage for Dairy Cattle. Rhode Island Agr. Expt. Sta., *Bull.* 311. 1950.

(3) LOOSLI, J. K., HUFFMAN, C. F., PETERSEN, W. E., AND PHILLIPS, P. H. Recommended Nutrient Allowances for Domestic Animals. III. Recommended Nutrient Allowances for Dairy Cattle. *National Research Council.* 1950.

(4) QUICKE, G. V., PHILLIPS, P. H., AND DREHER, W. H. An All-Roughage Ration for Bulls. *J. Dairy Sci.*, 33: 870. 1950.

EFFECT OF METHOD OF FEEDING METHIONINE AND POTASSIUM OROTATE TO YOUNG CALVES[1]

J. M. WING

Department of Dairy Science, University of Florida, Gainesville

Twenty-one calves of the Holstein, Guernsey, and Jersey breeds were divided into three comparable groups. They were allowed to nurse once, then removed from their dams and confined to individual pens. The colostral period was four days, whole milk was fed for five through 21 days, then reconstituted skimmilk was fed. Chopped Alyce clover hay and mixed concentrates were always available. The rations were adequate in vitamins and minerals. When potassium orotate and methionine were fed, either by capsule or in milk, the calves gained 25% more weight than their controls. Height at withers and efficiency of feed conversion were unaffected. *Editor.*

Orotic acid has been shown to promote growth in mice *(6, 7)*, rats *(5)*, and various strains of bacteria *(3)*. Natural materials which are rich in this substance have been reported to contain an unidentified growth factor for chicks *(2, 4, 8)*. Orotic acid, when fed with methionine, stimulated growth in pigs *(1)*, and the potassium salt was beneficial to yearling heifers *(10)*. Methionine and orotic acid accelerated the growth of young calves, when the supplements were fed twice daily by gelatin capsule and thus probably went into the rumen. However, much less response was observed when the supplements were dispersed in milk, which was fed from nipple-pails and probably went directly into the abomasum *(9)*. The difference may have been owing to the fact that orotic acid is only slightly soluble. Thus, capsule administration possibly allowed more of this supplement to dissolve in the gastric fluids, because of its longer contact with them.

The present work was undertaken to determine if potassium orotate, which is readily soluble, would benefit young calves when fed with supplemental methionine and, if so, whether capsule feeding is necessary, or if the supplements can be fed in the milk.

EXPERIMENTAL PROCEDURE

Twenty-one neonatal calves of the Holstein, Guernsey, and Jersey breeds were allocated to three groups which were comparable in breed, sex, body weight, and height at withers. Subjects were allowed to nurse once, then were removed from their dams and confined to individual pens.

The colostral period was four days. Whole milk was fed from five through 21 days of age; thereafter, reconstituted skimmilk was used. All milks were fed from nipple-pails at the rate of 9% of body weight, in two equal feedings daily.

Fifteen thousand I. U. vitamin A in the form of fish liver oil were dispersed in each 9 lb. of milk, fed after the colostral period.

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Chopped Alyce clover hay and dry mixed concentrates were offered free choice. The concentrate feed contained, in parts, ground oats, 50, ground shelled corn, 60, wheat bran, 40, dried skimmilk, 20, cottonseed meal (41% crude protein), 26, common salt, 1, and steamed bonemeal, 2. Refused dry feed was weighed, removed, and replaced daily with a fresh allowance.

The calves in Group 1 received no additional dietary treatment and served as a control. Group 2 received 110 mg. per 100 lb. body weight of methionine and of potassium orotate by capsule, at each of the two daily feedings. Group 3 received the same supplements in the same amounts as Group 2. For Group 3, however, the potassium orotate and methionine were dispersed in the milk.

On the afternoon of the fourth day postpartum all subjects were weighed, and height at withers was measured. Subsequently, measurements and weights were recorded at weekly intervals. At least three times daily, all calves were observed for evidence of scours or other abnormalities.

RESULTS

General health. One calf in the control group scoured for two days, but no other abnormalities were observed. All animals were sleek and alert. No differences in general health were discernible between groups.

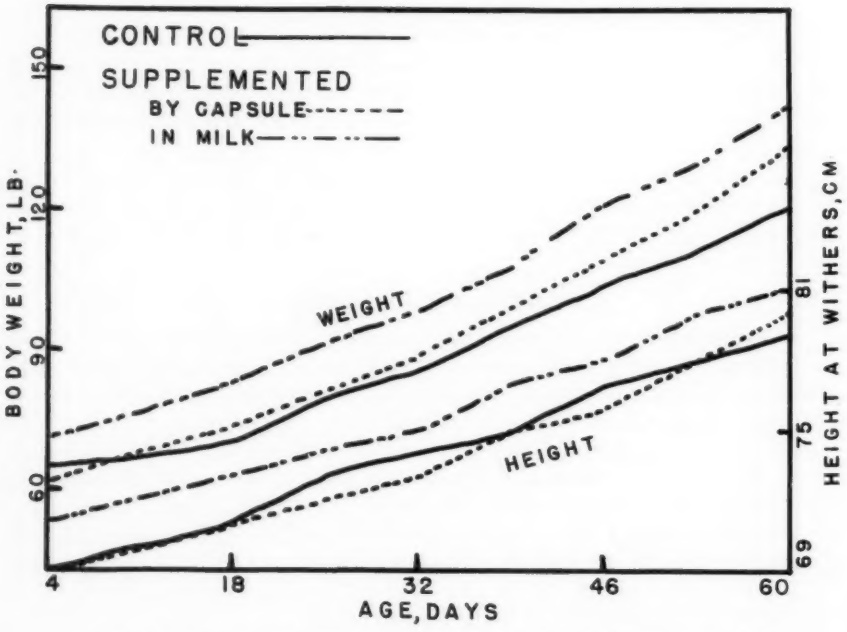

FIG. 1. Effect of potassium orotate and methionine on growth of young calves.

Effect on rate of growth. The calves in Groups 2 and 3 grew at an almost equal rate. The group mean gains of these groups were 71 and 72 lb., respectively. Control calves gained an average of 57 lb. (Figure 1). The differences between supplemented and control groups were quite consistent, and were significant at $P = 0.01$.

Changes in height at withers were above average in all subjects, and no significant differences were observed (Figure 1).

Effect on feed consumption. The calves in Groups 2 and 3 consistently consumed more concentrate feed than those in Group 1. This seems to have been directly in proportion to the superiority of the average gains made by Groups 2 and 3, because they required about the same TDN per pound gained as did Group 1 (Table 1).

TABLE 1

Relation of supplementation with potassium orotate and methionine to feed intake and efficiency of feed conversion in dairy calves between the ages of four and 60 days

Group	Feed intake				Mean calculated TDN per pound gain[a]
	Whole milk	Skim-milk	Concentrate	Hay	
	(lb.)				
Control	107.0	317.8	37.8	10.9	1.47
Supplemented by capsule	107.5	355.7	61.7	16.6	1.51
Supplemented in milk	124.9	375.1	60.6	11.0	1.50

[a] Morrison, F. B. *Feeds and Feeding.* 21st ed. Morrison Publ. Co., Ithaca, N. Y.

DISCUSSION

Environmental conditions appeared to be superior to those surrounding previous work *(9)*, because it was observed that comparable control calves grew faster than previously. This in part may explain the fact that response to supplementation was only a 25% increase in weight gained, as compared to 46% previously reported. It also may explain, in part, the fact that this experiment has failed to corroborate the previous report, of an increase in efficiency of feed conversion upon supplementing with orotic acid and methionine. However, it cannot explain the fact that the present report shows a response to both capsule and milk feeding; whereas, methionine and orotic acid per se produced significantly superior results only when fed by capsule *(9)*. Orotic acid is a bacterial growth factor *(3)*; thus, it seemed likely that its effect on calf growth was caused by stimulation of the rumen flora. The possibility that gastric and/or enteric bacteria are involved can not be eliminated as yet. It now seems more likely, however, that the supplements were used directly by the animal tissues. Studies with isotopically labeled orotic acid showed it to be a precursor of nucleic acids in the rat *(5)*. The role of methionine in this conjunction remains obscure. That it is synergistic with orotic acid, however, has been confirmed in growth studies with mice *(6)*. The fact that a soluble orotate was used as effectively when fed in milk as when administered by capsule indicates that the present level of supplementation may have been much higher than is desirable.

SUMMARY

When fed potassium orotate and methionine, either by capsule or in the milk, young calves gained 25% more weight than comparable controls. Height at withers and efficiency of feed conversion were not affected.

ACKNOWLEDGMENTS

The author is indebted to Mr. H. L. Somers for management of the animals and help with the records. Thanks also are extended to Specifide, Inc., Indianapolis, Indiana, for the feed supplements used in this work.

REFERENCES

(1) ANONYMOUS. Last-Minute Report. *Farm J.*, p. 20. April, 1952.
(2) BERRY, E. P., CARRICK, C. W., ROBERTS, R. E., AND HAGUE, S. M. Whey Solubles as a Source of Growth Factors in Chick Rations. *Poultry Sci.*, **22**: 252. 1943.
(3) CHATTAWAY, F. W. Growth Stimulation of *Lactobacillus Casei* by Pyrimidines. *Nature*, **153**: 250. 1944.
(4) HILL, F. W. The Multiple Nature of the Deficiency of Unidentified Nutrients in Crude All-Vegetable Protein Chick Starter Rations. *Poultry Sci.*, **27**: 536. 1948.
(5) HULBERT, R. B., AND POTTER, V. H. A Survey of the Metabolism of Orotic Acid in the Rat. *J. Biol. Chem.*, **195**: 257. 1952.
(6) MAKINO, K. Personal correspondence. 1956.
(7) MAKINO, K., KINOSHITA, T., SATOH, K., AND SASAKI, T. Orotic Acid as One of the Growth Factors of Mice. *Nature*, **172**: 914. 1953.
(8) MENGE, H., COMBS, G. F., HSU, P. T., AND SHORB, M. S. Unidentified Growth Factors Required by Chicks and Poults. I. Studies with Chicks Using Purified Diets. *Poultry Sci.*, **31**: 237. 1952.
(9) WING, J. M. Effect of Orotic Acid and Methionine Supplementation on Feed Consumption and Growth of Young Calves. *J. Dairy Sci.*, **38**: 504. 1955.
(10) WING, J. M. Effect of Potassium Orotate and Methionine Supplementation on Feed Consumption and Growth of Dairy Heifers. *J. Dairy Sci.*, **40**: 335. 1957.

RESPONSE OF GROWING DAIRY HEIFERS TO FREQUENCY OF FEEDING[1,2]

A. H. RAKES,[3,4] W. A. HARDISON, J. ALBERT, W. E. C. MOORE, AND G. C. GRAF
Department of Dairy Science and Biochemistry and Nutrition
Virginia Polytechnic Institute, Blacksburg

Twelve dairy heifers were used in a single-reversal trial to study the effect of feeding equalized intakes of feed two and ten times daily on body weight gain, digestibility, rumination time, and rate of feed passage. The animals were fed chopped alfalfa–orchard grass hay of medium quality as the only feed. Maximum feed intake was established during a 21-day preliminary period and this level of intake was maintained throughout the two, 50-day experimental periods which followed. Frequent feeding significantly increased body weight gains and rumination time and significantly decreased feed digestibility. There was no statistically significant difference in the rate of feed passage between the two feeding schedules. *Editor.*

In the past, livestockmen paid little attention to the effect that frequency of feeding had on the efficiency with which animals converted feed to milk, meat, and wool. This is surprising, when one considers the feeding behavior of the animal in its native, or unconfined, state.

In its wild state, the animal takes food throughout the day and also undoubtedly at night. The quantity eaten and the frequency of intake is entirely dependent upon the desire of the animal and the availability of feed. This condition exists to a very large extent in the free-grazing animal. However, with the closely confined, or hand-fed, animal, both the quantity of feed eaten and the frequency of intake are regulated according to the judgment of the husbandman. Since this is a definite change from the feeding habits of the animal in its native state, it is conceivable that some change in the efficiency of feed utilization, if not the physiology of the animal, has occurred as a result of domestication.

Work both with sheep *(7)* and with cattle *(12, 17)* has demonstrated that frequency of feeding is important in livestock production. The present investigation was initiated to study the response of dairy heifers to equalized intakes of feed, two and ten times daily.

EXPERIMENTAL PROCEDURE

Twelve dairy heifers (eight Holsteins and four Guernseys), ranging in weight from approximately 300 to 500 lb., were used as the experimental animals. The

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[2] Data presented are based on a thesis submitted by the senior author to the Graduate School of the Virginia Polytechnic Institute, in partial fulfillment of the requirements for a Master of Science degree.

[3] Ralston-Purina Fellow.

[4] Present address: Department of Animal Husbandry, Cornell University, Ithaca, New York.

animals were selected in pairs, with the members of each pair having body weights as nearly alike as possible. One animal of each pair was then allotted at random to the twice-a-day feeding treatment and the other member to the ten-times-a-day feeding regime.

The animals were brought up to a maximum feed intake during a 21-day preliminary period. The level was adjusted so that the members of each pair received the same total daily feed intake, and this level was held constant throughout the subsequent two 50-day experimental periods.

During the first experimental period, one-half of the animals received their daily feed allowance in two equal feedings daily, at 8 A.M. and 5 P.M.; the remainder of the animals received the same quantity of feed, divided into ten equal portions and fed at hourly intervals between 8 A.M. and 5 P.M. At the end of the first period, the treatments were reversed abruptly and the feeding continued for another 50 days.

The feed consisted of medium-quality, alfalfa–orchard grass hay which was chopped (approximately 2 to 4 in. in length) to facilitate feeding and to discourage feed refusal. The hay was core-sampled periodically before chopping, for proximate analysis. The animals were individually fed and consumption data were obtained on a daily basis. Water and salt were provided ad libitum and steamed bonemeal was offered the animals periodically.

All animals were weighed on three consecutive days at the beginning and end of each experimental period. In addition, weights were taken on three consecutive days at ten-day intervals between the beginning and the end of each period.

Conventional digestion trials employing all animals were conducted during the latter part of each experimental period. Feces were totally collected over seven-day periods. During each digestion trial, rumination time of all animals was recorded for three nonconsecutive 24-hr. periods. Also, during the second digestion trial, rate-of-passage measurements were made on three animals from each treatment group. The technique used was essentially that suggested by Balch *(2)*. Hay particles (stained with crystal violet) and chromic oxide were employed as indicators. The method of Schurch *et al. (15)* was used for the chromic oxide analysis.

All appropriate data were subjected to an analysis of variance *(5)*.

RESULTS

As shown (Table 1), the difference in weight gain due to frequent feeding during Periods 1 and 2 was 109 and 162 lb., respectively. The total difference due to feeding frequency was 271 lb. All of these differences were found to be statistically significant ($P = 0.01$). During Period 1, the animals fed twice daily gained a total of 216 lb. During Period 2, when these animals were fed ten times a day, their total gain was 240 lb., a difference of only 24 lb. On the other hand, the animals fed frequently during Period 1 made considerably greater gains during the first period than during Period 2, when they were fed only twice daily. This was probably due to the fact that at the end of

TABLE 1
Effect of frequency of feeding on body weight gain
(Total gain per treatment group)

Experimental period	Fed daily		Difference due to frequent feeding[a]
	2×	10×	
	(lb.)		
1	216	325	109
2	78	240	162
Total	294	565	271

[a] All of these differences are statistically significant (P = 0.01).
[b] This difference is not statistically significant.

Period 1 the animals fed ten times daily were heavier than the control group; thus, their maintenance needs during Period 2 were greater, and because the level of feeding was held constant throughout the experiment, the heavier animals had less nutrients available for body gain.

Changes in body weight of each treatment group throughout both experimental periods are presented (Figure 1). It is apparent that the cumulative effect of frequent feeding tended to become greater with increasing time. The failure to gain weight, or the decrease in weight, evident in each group between the 30th and 40th day of Period 1, and the 90th and 100th day of Period 2, occurred at the same times the digestion trials were being conducted.

Since average daily feed consumption was identical for both groups (11.3 lb.), efficiency of feed utilization (pound feed per pound gain) was much inferior

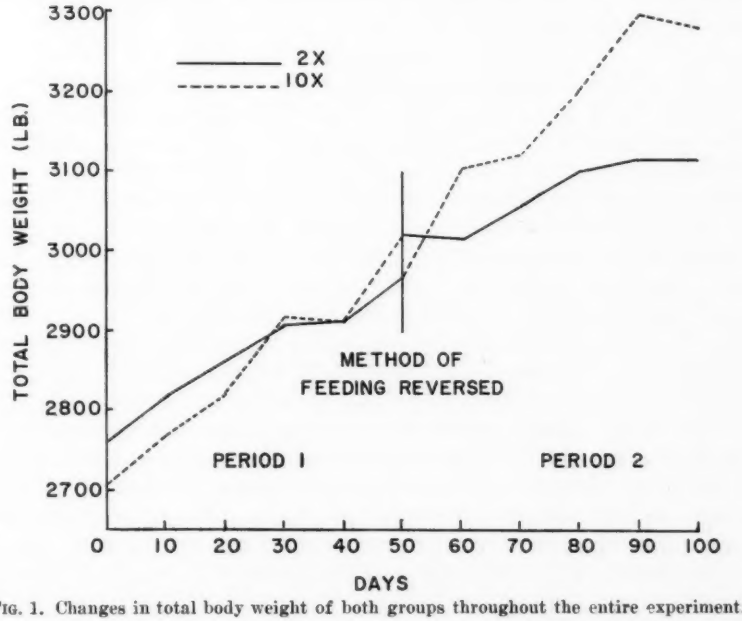

FIG. 1. Changes in total body weight of both groups throughout the entire experiment.

TABLE 2
Average coefficients of apparent digestibility

Treatment	D.M.[a]	C.P.[a]	E.E.[b]	C.F.[a]	N.F.E.[a]
			(%)		
2×	59.7	64.9	20.0	62.3	58.7
10×	56.9	63.0	17.4	58.9	55.1

[a] All of these differences are statistically significant ($P = 0.01$).
[b] This difference is not statistically significant.

for the animals fed twice daily. The average net efficiency of feed utilization was 11.4 and 5.3, respectively, for the twice-daily and the ten-times-a-day group.

A summary of the average coefficients of apparent digestibility is presented (Table 2). These data show that the digestibility of all constituents, except ether extract, was significantly higher ($P = 0.01$) for animals fed only morning and night, than for those fed ten times daily.

During both experimental periods, the frequently fed animals were observed to ruminate for significantly ($P = 0.05$) longer periods of times than the control animals. As would be expected, the frequently fed animals did the major portion of their ruminating at night. Only 37.2% of the total rumination time for this group was recorded during the period from 7 A.M. to 6 P.M. On the other hand, 58.9% of the total rumination time for the group fed twice daily was recorded during this period.

Frequency of feeding did not cause a statistically significant difference in the rate of passage of undigested feed residues. Also, no significant difference was obtained between the chromic oxide and stained hay–particle technique for measuring passage rate.

DISCUSSION

Results of this investigation are in agreement with those obtained by Thomas and Mochrie *(17)* and Mochrie *et al. (12)*, who reported that feeding dairy heifers four times daily resulted in significantly greater weight gains than when the same amount of feed was given either once or twice daily. It is of interest to note, in the studies of Mochrie *et al.*, that the milk production of first-calf heifers was not influenced by feeding frequency.

These results also agree with the findings of Gordon and Tribe *(7)*, with sheep. These workers have offered the following possible explanations for the greater weight gains with frequent feeding: *(1)* more efficient digestion, because of increased rumination time and greater microbial activity, *(2)* minimum loss of energy owing to faster passage rate, and *(3)* more uniform production of metabolites, which results in a more efficient utilization of the metabolites by the body tissues. Gordon and Tribe *(7)* presented no data to support points (2) and (3). In a limited study, they did find that the digestibility and retention of nitrogen were higher under frequent feeding conditions. These data do not agree with the digestion coefficients obtained in this study, which showed that digestion was more efficient when the ration was fed twice daily. The precise explanation for the difference in feed digestibility caused by frequency of feeding is not apparent.

It is difficult to know how to interpret the digestibility data and to relate them to body weight gain, because during the digestion trials the animals either lost weight, held their own, or made negligible gains. As shown in Figure 1, the animals fed ten times a day sustained greater losses than those fed twice a day. During the digestion trials, all of the bedding was removed from under the animals, lights in the barn were on continuously, and attendants were behind the animals all of the time. As far as the authors are aware, no one previously has shown that such changes will produce sufficient stress in the animal to result in body weight loss.

The data on rumination time obtained in this study are directly opposite to those obtained by Gordon and Tribe *(7)*, although their observation that rumination time is inversely related to digestibility was confirmed.

As mentioned previously, one possibility which has been suggested as an explanation for the results obtained with frequent feeding is, that when small feeds are given at frequent intervals the rate of passage out of the recticulo-rumen is faster; thus, energy losses due to bacterial fermentation are minimal. In the present study, no significant difference in the over-all passage-rate of feed, owing to frequency of feeding, was noted. However, this observation does not rule out the above possibility, because an increased rate of passage from the reticulo-rumen could be compensated for by a decreased rate of flow through the lower gut.

In view of the third suggestion offered by Gordon and Tribe, it is of interest to note that Finlayson and Baumann *(6)* found that the inclusion of 5% urea in the diet of rats, fed once daily, was as effective in inhibiting growth as a diet containing 30% urea fed ad libitum.

In addition to the explanations just given, certain other possible ones exist. One involves the production of heat, or the disposition by the animal of the heat produced during metabolic processes. In other words, is the heat increment of a ration influenced by frequency of feeding? It seems logical to assume that when the animal is fed once or twice daily, large quantities of heat are produced subsequently. The animal can not efficiently utilize this heat for productive purposes; thus, it has to expend considerable energy getting rid of it. On the other hand, where the ration is given in small amounts at frequent intervals, heat production presumably would be more uniform, or constant. Under these conditions, the animal is able to dispose of the small excess of heat with a minimum expenditure of energy, and more energy is available for productive purposes.

There are reports in the literature which would appear to support the above. In experiments designed to check the specific dynamic effects of a basal and a mixed diet, Richardson and Mason *(14)* found that when the mixed diet was divided into small portions and given at 2-hr. intervals, heat production was the same as when the basal diet was fed. Commenting on these experiments, Lusk *(10)* stated, "We may conclude from this evidence that if a mixed diet be so constituted as to conform to the exact needs of the tissues and be slowly intro-

duced by absorption from the intestines, its specific dynamic action is virtually negligible."

McClymont *(11)* concluded from an analysis of the available evidence that the high heat increment of feeding in ruminants is due, in large part at least, to the high specific dynamic action of acetic acid, a major product of microbial digestion in the reticulo-rumen. Butyric acid is also involved, but to a lesser extent. Theoretically, therefore, anything which influences the proportions of the nonglycogenic acetic and butyric acids, and the glycogenic propionic acid in the rumen, influences the net energy value of the ration. It may be theorized that frequent feeding increases the net energy value of the ration by this mechanism. If frequent feeding does alter the proportion of the volatile fatty acids produced in the rumen, and if milk production is not affected by feeding frequency *(12)*, then it is indicated that the ratio of these acids is not the same for maximum milk production as for maximum weight gain.

In considering the possible factors affecting the thermogenic action of food, Hamilton *(8)* stated, "The thermogenic action of food will vary depending upon the nature of the disposal of the absorbed nutrients. Thus, any condition of the animal, or number of times fed per day, or amount of feed at any one time, or composition of the feed which will result in a more efficient utilization of the absorbed nutrients, will invariably result in a lower thermogenic effect."

The precise explanation for the increased weight gains obtained under the conditions of frequent feeding is still obscure. It may be that a combination of several of the factors discussed is involved. On the other hand, a factor (or factors) yet to be uncovered may provide the answer.

Blaxter *et al. (3)* have discussed frequent feeding of animals with respect to the conduct of digestion trials. They concluded that frequent feeding at regular intervals is desirable and would minimize the errors involved in such trials. However, twice-a-day feeding is still the common practice among dairymen in this country, and it seems unwise to conduct research of an applied nature under conditions which are quite removed from the practical situation.

Because preliminary results from certain long-time experiments *(1, 4, 9, 13, 16)* indicate that rate of growth or degree of fatness is inversely related to milk production and length of productive life, frequent feeding of young animals which are being kept for production purposes may not be advantageous.

SUMMARY

A single-reversal trial has been conducted to study the response of growing dairy heifers to equalized intakes of feed, two and ten times daily.

Frequent feeding significantly increased body weight gains ($P = 0.01$), significantly decreased feed digestibility ($P = 0.01$), and significantly increased ($P = 0.05$) rumination time. No statistically significant difference was noted in the rate of feed-passage between the twice-a-day and the ten-times-a-day feeding schedules.

Possible reasons for these results, as found in experiments reported in the existing literature, and the practical significance of the findings, are discussed.

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REFERENCES

(1) Anon. Dairy Cattle Nutrition. Lifetime Project. Animal Research Div., N. Z. Dept. Agr., *Ann. Rept.* 19. 1955–56.

(2) Balch, C. C. Factors Affecting the Utilization of Food by Dairy Cows. I. The Rate of Passage of Food Through the Digestive Tract. *Brit. J. Nutrition*, **4**: 361. 1951.

(3) Blaxter, K. L., Graham, N. McC., and Wainman, F. W. Some Observations on the Digestibility of Food by Sheep, and on Related Problems. *Brit. J. Nutrition*, **10**: 69. 1956.

(4) Bonnier, G., Hansson, A., and Skjervold, H. Studies on Monozygous Cattle Twins. IX. The Interplay of Heredity and Environment on Growth and Yield. *Acta Agr. Suecana.*, **3**: 1. 1948.

(5) Cochran, W. G., and Cox, G. M. *Experimental Designs.* 1st ed. John Wiley and Sons, Inc., N. Y. 1950.

(6) Finlayson, J. S., and Baumann, C. A. Responses of Rats to Urea and Related Substances. *J. Nutrition*, **59**: 211. 1956.

(7) Gordon, J. G., and Tribe, D. E. Importance of Frequency of Feeding to Sheep. *Brit. J. Nutrition*, **6**: 69. 1952.

(8) Hamilton, T. S. Factors Affecting the Thermogenic Action of Food. Rept. Conf. Energy Metabolism, Pennsylvania State. 1935.

(9) Hansson, A., Brannang, E., and Claesson, O. Studies on Monozygous Cattle Twins. XIII. Body Development in Relation to Heredity and Intensity of Rearing. *Acta Agr. Scand.*, **3**: 1. 1953.

(10) Lusk, G. The Specific Dynamic Action. *J. Nutrition*, **3**: 519. 1931.

(11) McClymont, G. L. Specific Dynamic Action of Acetic Acid and Heat Increment of Feeding in Ruminants. *Australian J. Sci. Research*, **5**: 374. 1952.

(12) Mochrie, R. D., Thomas, W. E., and Lucas, H. L. Influence of Frequency of Feeding Equalized Intakes on Animal Response. *J. Animal Sci.*, **15**: 1256. 1956.

(13) Reid, J. T., Loosli, J. K., Turk, K. L., Asdell, S. A., and Smith, S. E. Progress Report on a Study of the Effect of Plane of Early Nutrition upon Reproductive and Productive Performance of Holstein Cattle. *J. Dairy Sci.*, **40**: 463. 1957.

(14) Richardson, H. B., and Mason, E. H. The Effect of Fasting in Diabetes as Compared with a Diet Designed to Replace the Foodstuffs Oxidized During a Fast. *J. Biol. Chem.*, **57**: 587. 1923.

(15) Schurch, A. F., Lloyd, L. E., and Crampton, E. W. The Use of Chromic Oxide as an Index for Determining the Digestibility of a Diet. *J. Nutrition*, **4**: 629. 1950.

(16) Swanson, E. W. The Effect of Fattening Dairy Heifers upon Their Growth and Lactation. *J. Dairy Sci.*, **40**: 463. 1957.

(17) Thomas, W. E., and Mochrie, R. D. Effect of Frequency of Feeding Equalized Intakes of Feed on Growth of Dairy Heifers. *Proc. Assoc. Southern Agr. Workers*, 123. 1956.

OUR INDUSTRY TODAY

Brief Reviews of Current Topics

Use of Antimicrobial Paints and Sealers in the Dairy Industry

J. H. RICHARDSON

Armour and Company, Research Division, Chicago, Illinios

Fungi and bacteria are great assets in many phases of food processing. They are of special interest in the production of many milk products in the dairy industry. Microorganisms are responsible for chemical changes, physical modification, and flavor development in milk, through many complex enzymatic reactions.

Existing concurrently with the desirable microbial species are many bacterial and fungal types which cause spoilage and down-grading of dairy products. Dairy bacteriologists have developed successful control measures in many areas of product processing and handling. The use of modern cleansing methods and sanitizers has brought about high bacteriological standards for processing equipment.

However, the accumulation of microorganisms in dairy plants, on walls, ceilings, and floors which are not subjected to exacting cleansing operations, can cause occasional outbreaks of defects in dairy products. Many airborne microorganisms become established in cracks and crevices of floors and walls, and on supporting structures in milk and cheese plants, and in creameries. Most materials used in construction of buildings—tile, bricks, cement, plaster, and wood—provide a surface upon which molds, yeast, and bacteria can survive and multiply. Water vapor, steam, air currents, and splashing in general will transport food materials to interior surfaces. This continual buildup of materials provides sufficient substrate to support the growth of many organisms.

Most building materials can be treated with antimicrobial agents. This prevention or limitation of an indigenous flora on plant structures will contribute to equipment cleanliness and, eventually, to improved product quality.

An effective antimicrobial agent for all such structural materials is Cunilate,[1] a soluble form of copper-8-quinolinolate. This material is relatively nontoxic and has been accepted for such use by certain regulatory agencies of the government. Cunilate can be added to most paints and varnishes and to suitable solvents.

In addition to the selection of antimicrobial agents for specific surfaces, special problems are found in the application of antimicrobial paints to old surfaces with deep-seated microbial growth, as contrasted to application to new materials.

Types of Antimicrobial Agents and Methods of Application

(1) New materials in processing rooms

The entire surface area should be treated with a penetrant sealer. Regular penetrant sealer for floors, which contains 50% solids, should be diluted to 15-20% solids with deodorized naphtha, in order to obtain proper absorption in unglazed tile. Plaster or cement ceilings should be given two coats of antimicrobial paint.

New buildings that have considerable areas of exposed lumber should have all the wood treated with 10% Cunilate in mineral spirits or naphthalene. The Cunilate application should be followed by two coats of an antimicrobial paint. New cement floor can be treated in the same manner as new tile floors.

(2) Old surface materials with average microbial contamination

Bacteria and fungi will in time penetrate into cracks and fissures in brick, plaster, cement, and wooden surfaces. It is important to determine the depth of contamination in old construction before applying inhibitory and cidal agents, because depth of microbial penetration determines the method and type of treatment. The microbial population must be destroyed or removed, to insure adequate action by the antimicrobial agent.

Many materials used to formulate oil-base paints will support mold growth. This is also true of rubber- and water-base paints. Mold growth covered with one of these surface coat-

[1] Cunilate is manufactured by the Scientific Oil Compounding Company, Chicago, Ill.

ings will grow through the film, utilizing some of the materials as food sources. Although mold can not attack paint films to which a fungicidal chemical has been added, it can grow through interstices in such films and continue its development on the under-surface. This activity of fungi indicates the necessity for killing all of the growth on and in a surface before applying a sealer or paint containing inhibitory substances.

Where surface growth is limited to a depth of from 1/16- to 1/8-inch, it should be treated with 0.5% hypochlorite or 10% emulsified Cunilate 4520, to destroy mold growth. More than one application may be necessary. Detergents with bactericidal properties should be applied with brushes, to assist in removal of organisms from rough surfaces. Thorough rinsing of all cidal and cleansing solutions should precede any paint or penetrant application, to insure proper adherence of paint to the surfaces.

(3) Old surface materials heavily infected with microbial growth

A heavily contaminated surface should be cleaned and prepared *(2)*, and 10% Cunilate in mineral spirits or deodorized naphtha applied daily until the surfaces have been impregnated below the depth of infection. Standard bacteriological techniques for examination of surfaces must be modified, to determine this depth of infection. A penetrant sealer should then be applied, followed by two coats of a suitable Cunilated paint.

(4) Applications in dairy industry

Raw milk should be protected from any contamination due to unclean ceilings, walls, floors, or any type of building structure. Rooms used for cooling and holding milk on the farm should have the same treatment as pasteurizing and processing rooms in the milk plant. This applies to all structural material in the plant and to certain equipment used to contain products, i.e., bottle-washing rooms, cold-storage spaces, receiving-docks, etc. New milk trucks should have either penetrant sealer over the paint or two coats of paint containing antimicrobial agent. Milk cases may be dipped in Cunilate wood-sealer.

Receiving rooms in creameries should be treated with antimicrobial surface coverings, not only for protection against product contamination but as a means of preventing off-odors. Creamery space used in pasteurizing, churning, tempering, or packaging operations should be treated so as to reduce the incidence of microbial contamination. Certain pieces of equipment, i.e., wood or metal pallets on which butter is tempered, may be given several applications of penetrant sealer.

Cheese plants present special problems in the use of antimicrobial surface coverings, because of the long holding periods used to ripen the product. The cool and moist atmospheres of aging facilities are particularly conducive to mold growth. Newly painted surfaces have been known to develop heavy mold growth 6 wk. after a thorough scrubbing and cleansing. Cunilate applied in such areas, at a concentration of 14 oz. per gal. of paint, has retarded mycelial development for two years. Even areas devoted to curd formation, cooking, and storage, which are most subject to microbial growth on surfaces, have been kept clean by the use of appropriate sealers and paints. After a year of continuous use, a storage cooler originally painted with Culinate should be gone over with a penetrant sealer.

In summary, the use of penetrant sealers and antimicrobial paints in the dairy industry offers a means of additional cleanliness and sanitation for the manufacture of products of high quality.

Interregional Competition in Dairying Studied with an Electric Brain[1]

M. M. SNODGRASS AND C. E. FRENCH
Agricultural Economics Department, Purdue University
West Lafayette, Indiana

Many vital economic questions of the farm hinge upon the competitive relationship between one region of the country and another. Certainly, the current major questions in dairy economics arise in this economic atmosphere. For instance, what is the future of dairying in the South? Where would a successful fresh powder or concentrate be produced? How much will cheap commercial nitrogen reduce dairying in the Corn Belt? How big should a federal marketing order be? How far will the plant mergers go?

Interregional competition studies have plagued dairy economists. Everyone has known they are needed, but no one has been sure how they should be accomplished. Most studies have worked with rather restricted regional areas and have tackled only part of the products and institutions. These studies have utilized various approaches, including budgeting on individual farms *(4)*, a study of intermarket price relationships *(1)*, and econometric analysis *(5)*.

The large scale of the dairy industry, with its many complicating features, makes it difficult to formulate a satisfactory interregional analytical framework, especially when trying to emphasize the solution of dynamic problems. Any model used to depict interregional competition should embody the principle of specialization, the principle of comparative advantage, location theory, and the theory of general equilibrium. The full meaning of these economic principles need not delay us. Let it suffice to say that they would cover most of the economics of dairy production, marketing, and consumption!

This article describes a new approach to interregional studies—an approach which the authors believe will yield invaluable data to the dairy trade. This approach involves a new mathematical technique fostered by such problems as ship-scheduling in World War II and the Berlin airlift at the War's aftermath. Also, it involves the use of a large digital computer, or electric brain. This approach is precise, and thrives on broad-scale problems.

The New Approach

The electric brain is a large scale, scientific data-processing machine. Data are fed into the machine on a punched-paper tape much like a narrow version of the old player-piano roll. The brain can take 540 numbers a second and remember over 800,000 words of information. It can add ten-digit numbers at the rate of 400 per second. In general, it is of a type not too uncommon on modern campuses today, and it is available to most researchers.

The mathematical technique used is called the transportation model of linear programming *(7)*. In its simplest form it uses three types of data—production figures (supply), consumption estimates (demand), and a structure of transportation costs among the producing and consuming points. In theory, the problem is one of finding the lowest-cost shipping pattern for the products, so that all consumption needs will be satisfied from the given production. In practice, it is much more flexible than this, and other costs can be included.

This study used state data for consumption and production. Thus, the model consisted of 48 sources, each with a predetermined production, and 48 markets, each with a predetermined market need. Transportation data from major dairy processing companies were used.

From this very simplified model, which included transportation costs only, several variations were studied. For example, both supply and demand for milk were projected forward for the year 1965. Supply and demand were projected for each state (demand projected on the basis of expected increases in population). In solving for the optimal flow of product in the future, necessary adjustments to changes in supply and demand could be studied.

Another variation of this model was formulated to study the effect of market restrictions and trade barriers on the dairy industry. Any restriction which can be measured in terms of cost can be introduced into the transportation model. For example, to study the effect of state milk control in the 16 states having such control, the transportation cost of moving milk into these 16 states was increased to approximate the amount of protection afforded by state control *(9)*. Thus, the effect of restricted entry into protected state markets was studied.

To make the electric brain work harder, processing and transportation costs for the different manufactured dairy products were worked into the model *(6)*. To formulate this problem,

[1] Approved for publication as Purdue Journal Paper No. 1162, August 26, 1957.

states were aggregated into 24 regions, and consumption in each region was specified by product for fluid use, butter, cheese, and evaporated milk. Thus, using state total milk production figures and a structure of transportation and processing costs, the problem was one of determining the optimal location of processing plants by product, to minimize cost of processing. Simultaneously, the optimum movement of each product into consumption was derived in such a way as to minimize transportation costs. A variation of this model was formulated to study the effect of an expanded export market for butter, cheese, and evaporated milk on the domestic dairy economy. The answer from the electric brain pointed out the desirable adjustments which should be made, particularly in processing firm location, if this export situation should develop.

To complicate the problem still further, the cost of producing milk was added to the costs involved in processing and transporting milk. Solutions to this problem indicated the most profitable location for dairy farms, in addition to the most optimum location for dairy processing plants. A variation of this model allowed study of the effects of the new innovation—fresh concentrated milk. Since it is possible to mix one quart of this concentrate with two quarts of water to make three quarts of milk, the effect is to reduce transportation costs for fluid milk by two-thirds, and to add a processing charge for making the concentrate *(10, 11)*.

Answers Given by Electric Brain

What are the answers to some of the above problems? In general, it was concluded that:

1. The transportation model of linear programming is applicable for dairy interregional studies. However, many areas lack good data, and extensive use of the mathematical model and brain will require better data.

2. Few data were available relative to actual movements of products. Thus, it was difficult to check the answers which the brain gave against the present actual situation.

3. General transportation-rate data applicable to this type of study can be secured. However, for more specific problems, transportation-cost data are costly to obtain.

4. Processing- and production-cost data are difficult to secure. Data good enough even to indicate direction of relationships do not come easily. However, by keeping the problem formulation small, proper data can be derived. However, precise answers on a national level will require better data.

5. In general, optimum movements of milk formed continental divisions tending to minimize costs as follows:

Exporting Region	*Importing Region*
Wisconsin	East, New England
Minnesota	West, South, Southeast
Iowa	South, Southeast
Kansas	South
Nebraska	Southwest
Utah	West

6. The above general pattern of movements was found throughout the models until production costs were introduced. When current production-cost estimates were included, answers suggested greater concentration of production and product manufacture in the Lake States. However, if areas such as the South can reduce costs of production to the level of those in Wisconsin, then decentralization would be the trend expected, and would be desirable from the standpoint of minimizing cost to the industry.

7. Variations in the models indicated that shifts in the population in the next ten years would not materially affect the optimal aggregate movements of products relative to direction.

8. The acceptance of fresh concentrate by consumers as equal to whole fluid milk would result in the fresh concentrate capturing 44% of the market for fluid consumption.

9. The introduction of state milk-control agencies in the 16 states having controls had little effect on patterns of movement. However, the result suggested that a little restriction may cause a rather large increase in cost to the industry. An increase in transportation cost equivalent to 5% of the average farm price, for milk moving into the 16 states having milk control, resulted in a 9.5% increase in the total transportation bill.

Other Problems Which the Electric Brain Can Help Solve

Thus far, we have discussed only one of the models of linear programming, and have discussed only a few of the problems in the dairy industry—primarily those concerned with interregional competition. However, there are many other types of problems which the electric brain can help solve.

Some work is in progress. For example, U.S. Department of Agriculture researchers are feeding the records of some 100,000 milk producers into one of these machines, in an attempt to determine the most economical and reliable method of sampling and measuring the butterfat content of milk. New York researchers claim they can evaluate the D.H.I.A. records of 70 cows per minute with their machine. Other agricultural problems which are being tackled with the help of the electric brain include how to decide whether to buy or raise beef steers, what rotations and fertilizer practices to follow, how much a particular building is worth, how long to hold broilers, what type

of lease is best, effect of farm programs, and best rations to feed livestock.

The machine can help solve problems both in farm management and in marketing. Some marketing problems which can be studied include alternate methods of curing pork, hog-price forecasting, feed-mixing problems *(2)*, grain elevators, and lowest-cost methods of making cheese-spread or ice cream *(3)*. A problem which has recently been completed at Purdue is one designed to tell milk-plant managers which products to produce, and what packages to use, for most profit *(8)*.

In summary, if researchers can feed the proper data into the electric brain, it will enable researchers to solve many problems they could not solve before, merely because they were too big and complicated. There is no reason why these machines cannot help solve problems for the dairy industry just as they are doing in many other industries.

REFERENCES

(1) Bredo, William, and Rojko, A. S. Prices and Milksheds of Northeastern Markets. Northeast Regional Publication No. 9. Mass. Agr. Expt. Sta., *Bull.* 470. 1952.

(2) Hutton, R. F., and Allison, J. R. A Linear Programming Model for Development of Feed Formulas Under Mill-Operating Conditions. *J. Farm Economics*, 39: 94. 1957.

(3) Katzman, I. Solving Feed Problems Through Linear Programming. *J. Farm Economics*, 38: 420. 1956.

(4) Mighell, R. L., and Black, John D. *Interregional Competition in Agriculture.* Harvard Univ. Press, Cambridge, Mass. 1951.

(5) Rojko, A. S. An Application of the Use of Economic Models to the Dairy Industry. *J. Farm Economics*, 35: 834. 1953.

(6) Snodgrass, M. M. Linear Programming—A New Approach to Interregional Competition in Dairying. *J. Farm Economics*, 38: 1507. 1956.

(7) Snodgrass, M. M., and French, C. E. Simplified Presentation of "Transportation-Problem Procedure" in Linear Programming. *J. Farm Economics*, 39: 40. 1957.

(8) Snyder, J. C., and French, C. E. Selection of Product Line for a Fluid Milk Plant by Activity Analysis. *J. Farm Economics*, 39: 914. 1957.

(9) Spencer, Leland, and Christensen, S. K. Milk Control Programs of the Northeastern States, Part I—Fixing of Prices Paid and Charged by Dealers. Northeast Regional Pub. No. 21. Cornell Univ. Agr. Expt. Sta., *Bull.* 908. 1954.

(10) Utter, K. L. *et al.* Methods and Costs of Processing and Delivering Fresh Concentrated Milk in Rural Areas. Iowa State Coll. Agr. Expt. Sta., *Special Rept.* No. 14. 1945.

(11) Ward, E. H., and Cook, H. L. Concentrated Milk: Some Aspects of Costs and Acceptance for Retail Distribution. Wisconsin Agr. Expt. Sta., *Agricultural Economics* 12. 1954.

Formulas Made from Cow's Milk Provide Infants' Needs for Proteins and Amino Acids

Frank E. Rice, Ph.D.

Research Adviser, Evaporated Milk Association, Chicago, Illinois

Much progress has been made in recent years in determining the quantitative needs of the normal infant for protein and the essential amino acids. The purpose of this paper is to review the findings and opinions of competent investigators on the needs of the infant and to determine how these needs are satisfied by human milk and by formulas prepared from cow's milk.

It is a more difficult problem to measure the requirements of the infant for a nutrient than to determine the requirements of a rat. There are more factors that cause humans to differ in their ability to digest and absorb food. It is advisable, therefore, that once the minimum requirements for protein or other nutrients have been estimated on a selected group of supposedly average human beings of whatever age, a percentage should be added for an optimum dietary intake.

Protein Requirements; Protein Intakes

More work has been done with adults than with babies on minimum protein requirements. It has been established, however, that the young baby needs two to four times as much protein as does the adult, per unit of body weight. This is due to the high growth rate of the infant and also its higher unit requirement for maintenance.

Human milk is relatively low in protein. It averages about 1.2 g. protein per 100 ml., with wide variations among individual nursing mothers *(12)*. Cow's milk contains 3.3 g. per 100 ml. on the average *(12)*.

The National Research Council (NRC) *(13)* concludes that the breast-fed baby may receive 2 to 2.5 g. of protein per kilogram of body weight per day, although it has been observed that often breast-fed babies receive even less

than 2 g. *(3)*. The NRC allowances represent a consensus on the dietary needs of the infant, based on very limited data.

An interesting calculation made by Hegsted *(6)* led to the conclusion that during the first month of life the minimum amount of protein required for normal growth and maintenance is nearly 2.5 g. protein/kg/day, and somewhat higher for large male babies.

The average infant formula contains about 2.3 g. protein per 100 ml., nearly twice the protein content of average human milk. Protein level has often been stated in another way. Human milk carries about 9% of the total calories as protein, whereas protein calories in formulas prepared from cow's milk are 15%, or higher. Calculations made from the way tissues are deposited and maintained in the human body led to the advocacy of diets, for all ages, in which at least 15% of the calories come from protein *(7)*.

Some clinical and laboratory studies have reported higher nitrogen retentions, better muscle development, and larger weight gains when babies were fed cow's-milk formulas, as compared with human milk *(9)*. It should be mentioned, however, that it is questionable if these criteria are sufficient to conclude that higher protein levels than those in human milk are better for infant nutrition.

Insofar as animal experiments may be accepted, in answering the question of optimum protein levels, it is known that better growth has been observed in young rats on diets containing protein at levels higher than those contained in human milk *(5)*.

Assumptions have been made that in human milk there may be some protein-sparing substances which would cause the limited amount of protein to be used more efficiently, but nothing of real significance has been demonstrated. For instance, human milk contains a proteolytic enzyme that could possibly aid in the digestion of protein in the intestine *(16)*. It is questionable whether this enzyme can survive the action of digestive juices in the stomach before passing to the intestine, and how much catalytic effect it can exert in causing human-milk protein to be more effectively utilized.

The National Research Council *(13)* discussed at length the difficulty in specifying just what the allowance should be for protein in infant-feeding. It points out that the requirement is highest in the early months of life and decreases with declining growth rate. The conclusion is reached (at any rate, until more information is available) that whereas the breast-fed infant evidently receives less, the dietary allowance for the formula-fed baby should be 3.5 g. of protein per kilogram of body weight per day.

Formulas containing cow's milk with added carbohydrate, generally recommended by pediatricians, will be found to supply at least 3.5 g. protein/kg/day under normal feeding conditions. An examination of published data points to an average of about 3.7 g. for most formulas.

Protein Requirements in Relation to Essential Amino Acids

Protein serves our dietary needs mainly as a carrier of amino acids, which are used in building new tissue, in the repair and maintenance of old tissue, and in other special metabolic functions.

There are 11 amino acids important for consideration in infant feeding. Eight of these are well established as indispensable for adults, since they are not synthesized in the body. Two others, arginine and histidine, should be provided in the diet, since the infant may not be able to synthesize its own supply as fast as needed. The amino acid, cystine, is also significant, because it can substitute for methionine in some of the metabolic processes.

In recent years, the amino acid requirements of babies have been studied in a number of research centers. In two clinics, actual determinations have been made for some of the amino acids, and for others, minimum requirements have been estimated *(1, 8)*. The values determined, including ranges where the findings have differed, together with estimated requirements for those amino acids that have not been actually measured, are recorded (Table 1). It is seen that for a number of the acids, the range of reported values is wide. For the most part, the higher figures come from one clinic and the lower ones from another. The differences appear to be due, in part, to the different methods employed and, in part, to the fact that relatively few babies have been available for study.

No doubt, in time, additional information will be forthcoming from these clinics and others. Some of the variable factors that may have been overlooked in these studies may be discovered and controlled. Meanwhile, the data already released are extremely useful for comparing present feeding practices with apparent infant needs.

Discussion of the Amino Acid Data

First of all, it should be remembered that figures (Table 1) have been determined and proposed as minimum requirements for normal, average babies, when all other nutrients are controlled at optimum levels. Obviously, it is desirable that something above these minima be provided as safe dietary allowances. All babies are not average. One that grows fast will have greater nutrient needs than one that grows slowly. A period of protein depletion through illness, or from any other cause, such as temporarily deranged digestive or absorptive

TABLE 1

Amino acid requirements (minimum) for infants, and estimated intake from human milk and cow's-milk formulas

	1 Infant requirements kg/day in mg.[a]	2 Human-milk protein: 2.5 g. contains in mg.	3 Cow's-milk protein: 3.7 g. contains in mg.
Arginine	126	105	141
Histidine	30-63	48	89
Isoleucine	90	180	237
Leucine	425 (?)	335	400
Lysine	90-210	165	289
Phenylalanine	90-169	133	192
Threonine	60-87	130	170
Tryptophan	30	45	56
Valine	90-161	188	255
Methionine	85	48	96
Cystine	18	60	33

[a] Ranges of values published, as having been determined, or as proposed, by Albanese, Holt, Snyderman, and coworkers *(1, 8, 15)*. (See also other publications of these authors.)

capacity, may increase the subsequent metabolic demand.

Infant intake of amino acids from human milk (Table 1) is calculated on the assumption that the breast-fed baby receives 2.5 g. of protein per kilogram of body weight per day. As already stated, there is evidence that the intake is usually less. These values should be regarded as maximum.

Amounts of amino acids carried by 3.7 g. of protein, that would be received by an infant from a cow's-milk formula with added carbohydrate, are shown (Table 1).

In calculating the data (Table 1), the average percentages of the various amino acids in human- and cow's-milk proteins compiled by the National Research Council *(12)* were used. This publication reveals the widely different analyses reported by the various laboratories for these proteins. In using these figures, therefore, it is well to make allowances for wide sample differences, as well as for a lack of precision in the methods used by different laboratories in making amino acid determinations.

Results (Table 1) show that when the breast-fed baby receives 2.5 g. of protein, its intake is scarcely above the apparent requirements and, in judging intake-adequacy, one would need to assume that the protein is 100% digested, that the amino acids are 100% utilized, and that the milk is adequate with respect to other nutrients that affect the need for, and the utilization of, the essential amino acids.

An average cow's-milk formula, on the other hand, furnishes the essential amino acids, in general well above the minimum requirements.

The requirement for leucine is questioned, because it has not been actually determined. Some calculations on food intakes of normally growing infants have shown that the leucine intake was at the rate of 200 to 300 mg/kg/day *(2)*. If this satisfies the requirements for this amino acid, then it can be concluded that either a human-milk or a cow's-milk formula provides adequate amounts.

Whether there is a need to supplement infant-feeding formulas with lysine is controversial. The data show that the intake of this amino acid from a milk formula is well above even the highest requirement figure that has been published.

The sulfur-containing amino acids, methionine and cystine, are extremely important. Here again, it seems that human milk provides a marginal amount, whereas more is supplied by the cow's-milk formula.

It is well that the cow's-milk formula furnishes an apparently adequate amount of tryptophan, because this amino acid is used not only in protein synthesis, but serves as a precursor of nicotinic acid, when the diet is deficient in this vitamin.

The quality of a protein and its efficiency in supplying dietary requirements depend to a considerable extent on the relative amounts of amino acids present, and how closely the pattern relates to dietary needs. A rough examination of the amino acid patterns in human- and cow's-milk protein may be made by arranging the figures (Table 1) in progressive order. This will demonstrate that these proteins are much alike and, indeed, come close to the order of amino acid requirements of the infant. This supports the conclusion, reached also from direct determinations of their biological values, that the proteins of human and cow's milk have essentially equal nutritional value for the baby *(8)*.

Too Much Protein?

Starting many years ago, the contention was sometimes made that the higher protein level in cow's-milk formulas gives the baby too much protein and that, in consequence, its metabolic and waste disposal functions might be overloaded.

From the observations made, it is clear that neither the apparent protein needs of the baby nor its minimum requirements for essential amino acids are greatly exceeded in formulas usually prescribed. If, to minimum requirements, a percentage is added for safe allowances, there would be no excess.

There are reports from many sections of our country on infant feeding with cow's milk, without the usual addition of carbohydrate. In some medical centers, this type of formula is used exclusively *(11)*. Such a formula may give a baby as much as 5 to 5.5 g. of protein per kilogram of body weight per day, about

40% more than is contained in the average formula with carbohydrate. Thousands of babies have been so fed without reported incident.

Also, it has been observed in many protein researches that the adverse effects from relatively high protein feeding occur only when that protein is extremely low or exceptionally high in one or two of the essential amino acids. Well-balanced proteins, such as the milk proteins, can be fed in moderate excess of the needs of the body, without harm.

Recently, the Committee on Nutrition of the American Academy of Pediatrics reported on its examination of the question of whether the higher protein and electrolyte content of cow's milk, as compared with human milk, may be harmful to the infant, because of a possible excess load of solutes presented to the kidneys for excretion. The Committee concluded that the milk formula as commonly prescribed, with added carbohydrate, is no problem to normal infants in their usual environment *(4)*.

Cow's-Milk and Human-Milk Proteins from Other Points of View

The human-milk protein composite and that of cow's milk exhibit marked differences in certain physical and chemical respects, other than in amino acid content. Human milk produces soft liquid-like curds in the infant's stomach. The protein of cow's milk forms large, hards curds, unless the milk has been heated to a considerable degree, or otherwise processed. It so happens that the exposure to heat in the evaporated milk–sterilizing process is capable of rendering the protein similar in character to human milk when coagulated in the infant stomach. The widespread use of evaporated milk and other curd-softened milks in making formulas has solved the curd problem.

The application of excessive heat to milk products, under laboratory conditions, has been found to reduce the biological value of the proteins. For this reason, attention has been focused on commercially manufactured evaporated milk, because it is subjected to high temperatures. The various dry milks also have been studied. Animal experimentation has shown, however, that under commercial processing conditions the total biological value of the proteins is not materially affected *(14)*. Some slight loss of lysine has been reported, either because of destruction, or because of a rearrangement of the protein molecule, which may reduce its availability to the digestive enzymes; but the percentage reduction is small. An examination of the data (Table 1) shows that the average formula is very high in lysine compared to infant needs. Any of the processed milks used in making formulas should adequately supply the infant's requirement for lysine.

There was a time when human-milk protein was thought to be superior for infant feeding to that from cow's milk, because of the higher percentages of albumin and globulin and lower percentages of casein. In cow's milk the ratios are reversed. This is no longer held to be a factor in infant nutrition.

On the other hand, it has been suggested that the high casein content in the cow's-milk protein constitutes a significant gain. Casein is high in phosphorus, important in bone- and tissue-building. The intermediate digestion products of protein, the peptides, higher in casein digestion, are specifically valuable nutritionally, and in increasing the solubility and absorption of calcium, iron, and perhaps other minerals *(10)*. Admittedly, the phosphorus needs of the infant have not been well established and little is known about the role of peptides.

It is the general consensus of those who are engaged in nutrition research, and those in medical practice, that it makes no difference to a baby whether its protein needs are furnished by human milk or by cow's milk, so long as the latter has been properly heated or processed to soften the curd.

Summary and Conclusions

In drawing conclusions from any dietary experiments, particularly from those involving protein and amino acids in human nutrition, a great many factors need to be taken into consideration, many of which can not be eliminated, no matter how well the research is planned. However, from information appearing in the literature up to this time, the following conclusions can be drawn:

1. The average infant formula prepared from cow's milk provides protein and the essential amino acids in about the quantities and ratios required by an infant for maximum growth, with a reasonable margin to spare.

2. Human milk of average composition appears to supply protein and amino acids at levels no more than marginal. A number of authors in recent years have made this observation *(1, 3, 6)*. The fact that breast-feeding is often successful, correlates with observations that the composition of human milk is widely variable; many mothers can produce milk that is well above average in essential nutrients. Also well known is the capacity of the infant to adjust to varying dietary intakes.

3. The amino acid pattern of the cow's-milk protein mixture compares favorably with that of human-milk protein, and with the infant-requirements pattern for the various indispensable amino acids.

4. There is no indication that under the usual formula-feeding routine the baby is receiving too high a level of protein.

5. The formation of curd in the infant's stomach, once a problem in feeding a cow's-milk formula in the first few months of life, is solved in modern practice through the use

in the formula of evaporated milk and other curd-softened milks.

6. The type of processing used in producing cow's milk for feeding formulas does not affect materially the biological value of the protein and the availability of its amino acids. The effect of heat has been questioned. However, it has been reported from a number of laboratories that losses from heating are slight and, therefore, unimportant to infant feeding.

REFERENCES

(1) Albanese, A. A. Protein and Amino Acid Requirements of Infants. *Pediatrics*, **8**: 455. 1951.

(2) Baptist, N. G., and de Mel, B. V. Growth and Amino Acid Intakes of Children on a Cereal-Legume-Vegetable Diet. *Brit. J. Nutrition*, **9**: 156. 1955.

(3) Beach, E. F., Bernstein, S. S., and Macy, I. G. Intake of Amino Acids by Breast-Milk-Fed Infants and Amino Acid Composition of Cow's Milk and Human Milk. *J. Pediat.*, **19**: 190. 1941.

(4) Committee on Nutrition, Am. Acad. Pediatrics. Water Requirement in Relation to Osmolar Load as It Applies to Infant Feeding. *Pediatrics*, **19**: 339. 1957.

(5) Cox, W. M., Mueller, A. J., and Ellington, R. C. Influence of Protein Level and Infant Formula Preparations on Growth and Reproduction in Rats. *Am. J. Digest. Diseases*, **90**: 583. 1955.

(6) Hegsted, D. M. Theoretical Estimates of the Protein Requirements of Children. *J. Am. Dietet. Assoc.*, **33**: 225. 1957.

(7) Hill, L. F. Infant Nutrition. *Am. J. Clin. Nutrition*, **3**: 75. 1955.

(8) Holt, L. E. Nutrition in Infancy and Adolescence. Chap. 34. Wohl and Goodhart, *Modern Nutrition in Health and Disease*. Lea and Febiger, Philadelphia. 1955.

(9) Jeans, P. C. *Feeding of Healthy Infants and Children*. Chap. 14. A.M.A. Handbook of Nutrition. Chicago, Ill. 1951.

(10) Mellander, O. Protein Quality. *Nutrition Revs.*, **13**: 161. 1955.

(11) Meyer, H. F. *Milk Mixtures Without Added Carbohydrate. Essentials of Infant Feeding for Physicians*. Chas. C Thomas, Publisher, Springfield, Ill. 1952.

(12) National Research Council. The Composition of Milks. Publication 254. Washington, D. C. 1953.

(13) National Research Council. Recommended Dietary Allowances. Publication 320. Washington, D. C. 1953.

(14) Schroeder, L. J., Iacobellis, M., and Smith, A. H. Heat Processing and the Nutritive Value of Milk and Milk Products. *J. Nutrition*, **49**: 549. 1953.

(15) Snyderman, S. E., Pratt, E. L., Cheung, M. W., Norton, P., and Holt, L. E. The Phenylalanine Requirement of the Normal Infant. *J. Nutrition*, **56**: 253. 1955.

(16) Storrs, A. B., and Hull, M. E. Proteolytic Enzymes in Human and Cow's Milk. *J. Dairy Sci.*, **39**: 1097. 1956.

OUR ASSOCIATION

NATIONAL RESEARCH COUNCIL— DIVISION OF BIOLOGY AND AGRICULTURE [1]

SUMMARY OF ACTIVITIES, 1956-57

W. E. KRAUSS

Representative to the National Research Council; [2] *Associate Director, Ohio Agricultural Experiment Station, Wooster*

Biology Council

Activities of this group have resulted in development of several important manuscripts:

Concepts in Biology

Research Structure and Support (to be published in *Science*)

Instrumentation in Bio-Medical Research—(NAS-NRC Publication No. 472)

Developmental Biology Conference Series (to be published in a series of volumes)

Committee on Educational Policies

Reports. Booklets on biological education at different levels are in preparation: *(1)* material from 130 high-school and college teachers will be used for a booklet on high-school biology, to be written during the summer and published in the fall; *(2)* "Improving College Biology Teaching" is ready for publication, and copies will be sent to biological departments and college and university administrators; *(3)* a report on graduate education will be ready by June.

Sourcebooks. More than 300 biologists have contributed over 1,300 exercises and manuals for the "Sourcebooks of Laboratory and Field Studies for College Courses in the Biological Sciences." An editorial panel set up in cooperation with the American Physiological Society is screening materials for physiology courses; the editorial panel for the introductory courses sourcebook will also screen courses. Ten college and university biologists and 20 high-school biology teachers (the latter selected on a competitive basis from 329 applicants) have been appointed to the writing conference to be held at Michigan State University, June 24—August 16, 1957—to develop a "Sourcebook of Laboratory and Field Studies for Secondary-School Biology Courses." A panel of six high-school teachers is completing an outline for the sourcebook and for high-school courses in general. A preliminary edition of the book will be tested in selected schools during 1957–58.

Curriculum conference. The Conference on Undergraduate Curricula in the Biological Sciences will publish proceedings of the conference.

Plans and prospects. A comprehensive proposal for the development of noncurricular courses in biology for laymen has been developed by the Committee's Subcommittee on Adult Education, and the AIBS has agreed to seek support to implement the plan. A broad program for improving college teaching through internships, faculty fellowships, and support for experimentation in teaching has also been formulated. Other activities under way include preparation of a statement on criteria for the selection of science textbooks; encouragement of summer apprenticeships in research for students; promotion of short-vacation institutes for students; a study on better teaching on the use of statistics; preliminary studies on the use of terminology in biology teaching; endorsement of the principle of giving qualified high-school teachers opportunity to do research; and cooperation in efforts to obtain better information on secondary-school science teaching, to develop better coordination of biology teaching at different levels, to improve training of technicians, to broaden the base of education in applied biology, and to provide better information on opportunities for careers in biology. The first version of the bibliography on biological education will also be ready for publication by June, 1957.

A general report on the Committee's first three-year term is also being written and will be widely distributed.

Food and Nutrition Board

The major activities of the Food and Nutrition Board, outside of the Food Protection Committee, have focused on protein and fat nutrition.

Protein nutrition. The two aspects of protein nutrition given attention are, *(1)* the possibilities and contraindications of improvement in protein quality of processed foods by supplementation with amino acids, and *(2)* the development of protein foods suitable for use in areas of the world where protein malnutrition is conspicuously prevalent.

Fat nutrition. Fats in human nutrition have

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[2] Forward to W. E. Krauss for publication.

become most popular for indictment in relation to atherosclerosis and heart disease. The Board's committee is attempting to assess the proper role of fats in human nutrition.

Food protection. The Food Protection Committee, through its standing Subcommittees on Food Technology, Pesticides, and Toxicology, and ad hoc subcommittees, has published reports on surface activity as a criterion of safety of chemicals for use in food, and safe use of pesticides in food production. In addition, the committee prepared a statement on the relation of chemical additives in foods to the incidence of cancer, and an information leaflet showing the organization and functions of the committee.

Details of these and other activities have been issued in the Board's Proceedings, Volume XVI, 31-58, October, 1956.

Agricultural Board

The Board formally activated six new committees on *(1)* Agricultural Meteorology and Climatology, *(2)* Economics of Fertilizer Use, *(3)* Plant Breeding and Genetics, *(4)* Plant Composition in Relation to Soil Nutrients, *(5)* Soil-Crop-Water Relationships, and *(6)* Soil and Water Conservation.

Full information about earlier activities of the Board and its committees is given in the Proceedings of the Board, Vol. VI, 25-35, October, 1956. Its recent publications are listed below:

The Fluorosis Problem in Livestock Production. A report of the Committee on Animal Nutrition. 17 pp., NAS-NRC Publication No. 381. $1.

A Review of Bloat in Ruminants. A report of the Committee on Animal Health. 64 pp., NAS-NRC Publication No. 388. $2.

Composition of Concentrate By-Product Feeding Stuffs. A report of the Committee on Feed Composition. 126 pp., NAS-NRC publication 449. $3.

Nutrient Requirements of Dairy Cattle. A report of the Committee on Animal Nutrition. 30 pp., NAS-NRC Publication No. 464, revised 1956. $1.

Agricultural Research Institute

Class A membership as of March, 1957, numbered 70.

Class B membership now numbers 97, including 25 scientific societies, 21 federal agencies, 44 state agricultural experiment stations, and seven other organizations.

The fifth annual meeting of the Agricultural Research Institute (ARI) was held October 15 and 16, 1956.

Special reports were presented by the ARI committees concerned with communications, conferences, and the recruitment of scientists.

The Institute re-elected Walter C. Dutton, Dow Chemical Company, President, and M. T. Goebel, E. I. duPont de Nemours & Company, Vice-President. Burt Johnson of the National Cotton Council was elected Secretary.

The Institute has published the Proceedings of its Fifth Annual Meeting (October, 1956) and of a Conference on 1957 Program on Pesticide Applications and Regulation (November, 1956).

Institute of Laboratory Animal Resources

Production standards. The chief task of the Institute this year has been the development of a series of production standards for laboratory mice in the areas of breeding, nutrition, disease, and housekeeping. These standards were established under a contract with the National Institutes of Health, as an adjunct to the program of the Cancer Chemotherapy National Service Center.

International Committee. This year has seen the establishment of an International Committee on Laboratory Animals, sponsored by CIOMS, UNESCO, and IUBS, charged with an international survey of laboratory-animal resources, exchange of information, definition of terms, and the design of animal production standards.

Handbook. The second edition of *A Handbook of Laboratory Animals* may be published in the fall of 1957. This book is expected to cover laboratory-animal care, management, breeding, and supply. It will include sections on animal nutrition, diseases of laboratory animals, genetics and breeding, primate procurement and production, education of animal technicians, laboratory-animal caging and housing, the procurement of animals from nature, the production of "disease-free" animals, and a catalogue of laboratory-animal suppliers.

Other activities. The Institute is engaged in the development of a program for better utilization of the primate resources of the world, with emphasis on the planning for primate production when normal channels of trade are restricted; a survey of the need for inbred guinea pig strains in research and testing, and the design and initiation of training courses for animal caretakers.

The Handbook of Biological Data

The *Handbook of Biological Data* was published by the W. B. Saunders Company in November, 1956. An Air Force edition appeared late in December. The two editions are almost identical, except for cover, and each contains 640 pages, including front material and index. More than 20,000 sheets of data from 4,000 contributors were condensed into the book. An additional 13,000 scientists throughout the world served as reviewers, appraisers, and advisers. Since the first of the year, Saunders has filled 2,687 orders, and 1,500 copies were

shipped by the Air Force. The volume is now in its second printing.

Currently, the Handbook staff is engaged in the preparation of four volumes, viz., *Handbook of Toxicology*, Volume II (*Anti-infectives*) and Volume III (*Pesticides*); *Standard Values in Circulation and Respiration*, and the *Handbook of Aquatic Biology*. Volume III of the *Handbook of Toxicology* will appear in three parts, of approximately 500 pages each.

On July 1, 1957, the Handbook Office undertook the preparation of three additional tomes, *Standard Values in Biochemical Composition, Structure, and Activity, Standard Values in Growth, Reproduction, and Life Histories*, and Volume IV of the *Handbook of Toxicology (Poisons and Poisoning)*. Future plans (1958) call for Volume V (*Industrial and Radiation Toxicology*), *Standard Values in Physiological Performances*, and a second edition of the abridged *Handbook of Biological Data*.

Renewable Natural Resources

The Special Committee on Renewable Natural Resources has issued its final report and has been discharged. This Committee recommended that a standing committee, or board, be set up in NAS-NRC to promote by appropriate means the care and wise use of our renewable natural resources. The Committee regarded the encouragement of basic research as a most appropriate and effective measure in this field.

The Fellowship Programs

This Division is responsible for the nomination of all persons who may be chosen to serve on committees or panels that evaluate applications for fellowships in biology and agriculture for the following agencies and fellowships: *(1)* NSF Predoctoral Fellowships, *(2)* NSF Postdoctoral Fellowships, *(3)* NSF Senior Postdoctoral Fellowships, and *(4)* Conference Board of Associated Research Councils, Committee on International Exchange of Persons, Fulbright Fellowships.

By custom, the committees of *(2)* and *(4)* above are regarded as Division committees; those of *(1)* and *(3)* as panels of committees of the Fellowship Office (but this distinction is of no significance—responsibility for the results is shared by the Division and by the granting agencies whose ground-rules affect nominations and selections).

The above committees have met as usual, and the awards resulting from their recommendations have been made, or are being determined. Statistics on relative numbers of applications in physical and biological sciences, and on the relative success of such applicants, as well as other comparative figures of possible interest, are available.

International Biology

The United States National Committee of the International Union of Physiological Sciences is making preparations for the XXIst Physiological Congress to be held in Buenos Aires, Argentina, in 1959.

Discussions are under way for bringing the U. S. National Committee of the International Union of Biochemistry within the framework of NAS-NRC. Exploratory meetings have been held, and a constitution is being drafted. The new U. S. National Committee would be sponsored by the three Divisions of Medical Sciences, Biology and Agriculture, and Chemistry and Chemical Technology; it would be linked administratively with the latter.

ANNUAL REPORT[1]
COMMITTEE ON JUDGING DAIRY PRODUCTS, A. D. S. A.
OKLAHOMA STATE UNIVERSITY, STILLWATER
JUNE, 1957

C. J. Babcock,[2] L. R. Dowd, P. A. Downs, E. L. Thomas, F. G. Warren, J. J. Willingham, and G. M. Trout, *Chairmen*

The Committee on Judging Dairy Products, A. D. S. A., under the direct supervision of C. J. Babcock, assisted by D. R. Strobel, U. S. Department of Agriculture, supervised the 35th Collegiate Students' International Contest in the Judging of Dairy Products, Atlantic City, New Jersey, October 29, 1956, in connection with the Dairy Industries Exposition. This was the 22nd contest sponsored jointly by the American Dairy Science Association and the Dairy Industries Supply Association, and the 35th for the American Dairy Science Association. Thirty-three college teams participated in 1956. They were from Alabama, California Polytechnic, Clemson, Colorado, Connecticut, Cornell, Georgia, Illinois, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, North Carolina, Ohio, Oklahoma, Pennsylvania, Purdue, Rhode Island, Rutgers, South Dakota,

[1] Published according to the policy stated in the *Journal of Dairy Science*, 40: 1369. 1957.

[2] Addresses are given in January Journal, 1957.

Tennessee, Texas Tech., Vermont, Virginia, Washington, West Virginia, and Wisconsin. The California Polytechnic Institute for the first time entered a team in the Collegiate Students' International Contest in the Judging of Dairy Products. This brings to 44 the number of colleges participating from the beginning of the Contest, 35 years ago. Total team participation is shown in the accompanying table.

The official judges for butter, cheese, milk, and ice cream were N. E. Fabricius, H. L. Wilson, D. A. Pettee, and J. H. Erb, respectively.

The ten high-ranking teams and individuals in the judging of butter, milk, cheese, ice cream, and all products were as follows:

BUTTER

Rank	*Individuals*	*Score*
1.	Fred Dryg, University of Minnesota	9.75
2.	Charles M. Mead, Iowa State College	9.84
3.	Richard F. Flowers, Ohio State University	10.00
4.	James E. Turner, University of Nebraska	11.34
5.	Gene L. Krajnak, Ohio State University	11.67
6.	Irvin Kilker, South Dakota State College	11.97
7.	Gus Gleiter, South Dakota State College	12.50
8.	Bruno Hutter, University of Connecticut	12.59
9.	John A. Burbank, University of Nebraska	12.67
10.	Wesley E. Eckert, State College of Washington	12.75

Teams

1.	Ohio State University	36.17
2.	University of Nebraska	38.18
3.	South Dakota State College	38.89
4.	University of Minnesota	40.50
5.	Cornell University	43.84
6.	Oklahoma A & M College	45.26
7.	University of Wisconsin	46.17
8.	Mississippi State College	47.17
9.	University of Connecticut	50.26
10.	Iowa State College	51.43

MILK

Individuals

1.	Lyle Suprise, University of Wisconsin	9.17
2.	Don W. Gibson, California State Polytechnic Institute	14.84
3.	William Breene, University of Wisconsin	15.00
4.	James Dolan, California State Polytechnic Institute	15.08
5.	Charles M. Mead, Iowa State College	15.58
6.	Fred C. Jaronitzky, Jr., University of Illinios	15.67
7.	Marlin Fouse, Pennsylvania State University	15.83
8.	Roger G. Hopper, Virginia Polytechnic Institute	15.84
9.	Frank W. English, North Carolina State College	17.08
10.	Gus Gleiter, South Dakota State College	17.50

Teams

1.	University of Wisconsin	49.17
2.	California State Polytechnic Institute	52.50
3.	Pennsylvania State University	57.35
4.	Iowa State College	58.25
5.	University of Illinois	59.69
6.	University of Nebraska	60.59
7.	South Dakota State College	61.35
8.	North Carolina State College	61.67
9.	University of Massachusetts	62.93
10.	University of Rhode Island	63.66

CHEESE

Individuals

1.	Thomas E. Quint, Kansas State College	23.84
2.	Thomas Ruzicka, Iowa State College	24.35
3.	Ronald Upshaw, Oklahoma A & M College	24.83
4.	Fred C. Jaronitzky, Jr., University of Illinois	24.84
5.	Robert C. Hakeman, Iowa State College	25.00
6.	Roland E. Sills, University of Georgia	25.09
7.	Donald T. Liden, North Carolina State College	25.51
8.	Charles M. Mead, Iowa State College	26.34
9.	James Foushee, Texas Technological College	26.50
10.	Don W. Gibson, California State Polytechnic Institute	26.93

Teams

1.	Iowa State College	75.69
2.	University of Illinois	83.33
3.	University of Vermont	84.01
4.	Pennsylvania State University	85.51
5.	Oklahoma A & M College	86.18
6.	Texas Technological College	86.67
7.	Kansas State College	87.33
8.	University of Tennessee	91.00
9.	West Virginia University	92.17
10.	University of Georgia	93.77

ICE CREAM

Rank	*Individuals*	*Score*
1.	Ronald Sappington, University of Maryland	27.50

2. Wesley E. Eckert, Washington State College 28.50
3. Jerome J. Donovan, University of Massachusetts 31.34
4. William E. Smith, University of Connecticut 33.00
5. Fred C. Jaronitzky, Jr., University of Illinois 33.17
6. Robert Oberlin, Ohio State University 33.50
7. Frank W. English, North Carolina State College 33.67
8. Richard A. McKellar, Clemson Agricultural College 33.76
9. Ramon C. Larsen, South Dakota State College 33.84
10. Arvin N. Hall, Mississippi State College 34.17

Teams

1. University of Maryland 104.42
2. University of Connecticut 105.51
3. Mississippi State College 107.34
4. Ohio State University 108.67
5. California State Polytechnic Institute 112.67
6. University of Illinois 113.18
7. Oklahoma A & M College 114.35
8. South Dakota State College 115.52
9. Cornell University 117.84

T10. Kansas State College 118.17
T10. State College of Washington 118.17

ALL PRODUCTS

Individuals

1. Fred C. Jaronitzky, Jr., University of Illinois
2. Don W. Gibson, California State Polytechnic Institute
3. Charles M. Mead, Iowa State College
4. Thomas E. Quint, Kansas State College
5. Richard A. McKellar, Clemson Agricultural College
6. Lyle Surprise, University of Wisconsin
7. Fred J. Steffens, University of Illinois
8. William O. Lenoir, Mississippi State College
9. Marlin Fouse, Pennsylvania State University
10. Richard F. Flowers, Ohio State University

Teams

1. University of Illinois
2. Iowa State College
3. Mississippi State College
4. Oklahoma A & M College
5. Ohio State University
6. University of Wisconsin
7. South Dakota State College

T8. University of Connecticut
T8. Kansas State College
T10. California State Polytechnic Institute

Dairy Industrial Fellows, 1956

Two fellowships were offered in 1956, carrying stipends of $1,800 and $1,650. A third fellowship was offered, pending entrance of 25 teams in the contest. An all-time record of 33 teams, five more than the 1952 record of 28 teams, participated; thus assuring the third fellowship of $1,500.

A list of the 1956 Dairy Products Judging Team members who received the Dairy Industries Supply Association Fellowships for 1956 follows:

Team	Rank in contest	Name of senior[a] recommended for fellowship	School selected for graduate work
Univ. of Illinois, Urbana P. H. Tracy, Head, Division of Dairy Technology	First	Norbert L. Miller 311 W. Oregon St. Urbana, Illinois	Cornell University Ithaca, New York R. F. Holland, Head, Dept. Dairy Ind.
Iowa State College Ames C. A. Iverson, Head, Dept. of Dairy Industry	Second	Declined	
Miss. State College, State College F. H. Herzer, Head, Dairy Department	Third	James C. Simmons Dairy Department State College, Miss.	Clemson, S. Carolina Agr. College J. P. LaMaster, Head, Dairy Department
Okla. A & M College Stillwater C. L. Norton, Head, Dairy Department	Fourth	John D. Wynn 1007½ West 4th St. Stillwater, Okla.	Michigan State Univ., E. Lansing N. P. Ralston Head, Dept. of Dairy

[a] Any senior (not necessarily a team member), majoring in dairy industry from the winning school, is eligible for consideration for the award.

COLLEGES PARTICIPATING IN THE COLLEGIATE INTERNATIONAL CONTEST FOR JUDGING DAIRY PRODUCTS

College	'16	'17	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'47	'48	'49	'50	'51	'52	'53	'54	'55	'56	No. of contests entered
1. Ala.														*				*	*	*												*	*		*	3
2. Ark.					*																															4
3. Calif.								*		*				*									*					*								5
4. Calif. Polytech.																																			*	1
5. Clemson																										*	*						*	*	*	3
6. Colo.																										1	*								*	3
7. Conn.	*						*			*	*			*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	25
8. Cornell	*		*				*									*	*	*	*	*	*	1		*	*	*	*		*	*	*	*	*	*	*	21
9. Fla.																										*										1
10. Ga.												*	*					*									*		*	*	*	*	*	*	*	11
11. Idaho																												*								1
12. Ill.														*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*				1	18
13. Iowa			*	*	*	*		1	1	1	1	1	*	*	1	*	*	*	*	*	*	*	1	1	*	*	1	*	1	*	*	*	*	*	*	*	32
14. Kans.										*	*	*	*	1	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	1	*	*	25
15. Ky.																														*			*		*	3
16. La.																					*															2
17. Md.			*	*			*									*						*		*	*	*	*		*	*	*	*	*	*	*	17
18. Mass.	*					*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	29
19. Mich.									*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	26
20. Minn.					*	*					*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	22
21. Miss.											*	*	*	*	*	1	*	*	1	*	*	*	*	*	*	*	*	1	*	1	*	*	*	1	*	25
22. Mo.																																		*	*	2
23. Nebr.	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	33
24. N. H.	*						*				*													*			*			*	*	*	*	*	*	11
25. N. Mex.																						*	*					*								3
26. N. C.										*	*																*		*	*	*	*	*	*	*	11
27. Ohio	*	*	*	1	1	1	*	*	*	*		*	1	*	*	*	1	1	*	1	1	*	*	*	1	*	*	*	*	*	1	1	*	*	*	34
28. Okla. A & M												*	*	*	*	*	*	*	*	*		*			*		*	*	*	*	*	*	*	*	*	15
29. Ont.														*	*					*		*			*							*					6
30. Oreg.						*		*	*	*	*	*	*	*																							8
31. Pa.	*				*		1	*	*	*	*			*	*				*		*	*	*	*	*	*	*	*	*		*	*	*	*	*	23
32. Purdue			*	*		*		*	*			*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	25
33. R. I.																																*				2
34. Rutgers															*					*				*									*	*	5
35. S. Dak.	*	*	1	*	*	*			*	*	*	*	*			*	*	*	*		*	*	*	*	*								*	*	*	23
36. Tenn.											*	*	*	*				*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*	21
37. Texas A & M																							*	*	*	*	*	*	*	*	*	*	*	*	*	8
38. Texas Tech.																					*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15
39. Utah																												*								2
40. Vt.	*														*	*						*		*	*		*		*			*			*	11
41. Va.													*		*									*	*		*				*		*	*	*	12
42. Wash.																												*								6
43. W. Va.					*	*		*	*	*	*	*	*	*	*	*	*					*							*	*	*	*	*	*	*	20
44. Wis.								*								*		*	*	*	*		*	*	*	*	*							*	*	19
Total Colleges Participating	9	3	7	5	8	9	7	10	10	13	15	14	15	17	16	18	17	19	17	18	17	23	14	21	22	19	26	18	26	23	28	23	26	26	33	

* = Years teams were entered.
1 = First place, all products.

Miscellaneous

Joint meetings with DISA. During the year, the Committee held a joint meeting with the Contest and Fellowship Committee of the Dairy Industries Supply Association at Storrs, Connecticut. Plans were discussed for furthering the best interests of the Contest and the Dairy Industrial Fellowship program.

Solicitation of coach-comments. Following the 1956 contest, coach-comments concerning the contest again were solicited. Coaches' comments were coded, assembled, and studied, with the aim of improving the 1957 contest in any way possible. The Committee was gratified at their frank responses, especially at the assurances that the contest with all its affiliations was fulfilling its functions satisfactorily.

1957 contest rules. Following a thorough study of the 1956 contest and coach-responses, the Committee considered the 1957 rules. Upon recommendation of the Committee, they were left virtually the same as the 1956 rules. Accordingly, in early spring, C. J. Babcock, USDA, produced and distributed the 1957 rules to the colleges of the United States and Canada.

Status of research under Fellowship grants. Because of the efforts of Mrs. Prescott, and the full cooperation of the dairy departments involved, the research program under the Fellowship grants is as up-to-date as completion of research and publishing of results can make it. Several theses have been received. Publication of several papers is now in process. Twenty-seven fellowships have been processed from 1947 (resumption of contests following World War II) to 1956, inclusive, bringing the total number of fellowships to 83 since the program was inaugurated in 1930.

Committee changes. L. R. Dowd and F. G. Warren replaced long-time A.D.S.A. Judging Dairy Products committeemen, E. O. Anderson and F. H. Herzer, respectively, July, 1956.

Conclusion. Again, the conclusion may be drawn as of a year ago, "Few committees have an opportunity to work as closely with industry as the Committee on Judging Dairy Products, A.D.S.A. This opportunity is fully appreciated. The 21 members of the Contest and Fellowship Committee, and their secretary, Mrs. Beatrice Prescott, make joint cooperation a pleasure. The Chairman is especially grateful to them, to Messrs. Babcock, Strobel, and Downs for administering the contest, and to the Committee members and coaches for their full cooperation."

PROCEDURES FOR MAKING ACIDITY TESTS OF FLUID MILK PRODUCTS [1]

F. J. Doan, *Department of Dairy Science, The Pennsylvania State University, University Park;* B. L. Larson, *Department of Dairy Science, University of Illinois, Urbana;* W. C. Winder, *Department of Dairy and Food Industries, University of Wisconsin, Madison;* and J. G. Leeder, *Chairman, Department of Dairy Science, Rutgers University, New Brunswick, N. J.*

The following procedures for testing the acidity of fluid dairy products are recommended to the dairy industry as standard tests. The acidity tests for chocolate milk were recommended to the American Dairy Science Association by a subcommittee [2] given this responsibility by the Association. All other procedures were described by Sommer [3] and approved by the Dairy Manufacturing Section.

Milk, skimmilk, buttermilk, and whey [4]

a) Measure 9 ml. of the product into a white cup.

b) Add three to four drops of indicator (1% alcoholic solution of phenolphthalein).

c) Slowly add N/10 sodium hydroxide from a buret, stirring the sample with a stirring rod.

d) When the first definite and relatively permanent shade of pink has been reached, read the buret to determine the ml. of N/10 sodium hydroxide used.

e) Multiply this reading by 0.1 to express the titer as the so-called per cent of lactic acid.

[1] Published according to the policy stated in the *Journal of Dairy Science.* 40: 1369. 1957.

[2] Doan, F. J., Larson, B. L., Winder, W. C., and Leeder, J. G., Chairman. Procedures for Making Acidity Determinations of Fluid Dairy Products. Report of the Subcommittee for Recommending Uniform Procedures, American Dairy Science Association. *J. Dairy Sci.,* 39: 1384. 1956.

[3] Sommer, H. H. The Acidity of Milk and Dairy Products. Wisconsin Agr. Expt. Sta., *Research Bull.* 127. 1935.

[4] An 18-g. Babcock pipet may be used for milk, skimmilk, buttermilk, and whey by doubling the amount of indicator and dividing the final result by two.

Sweet cream [5]

a) Measure 9 ml. of cream into a white cup.
b) Rinse the pipet with one filling of distilled water.
c) Add six drops of indicator (1% alcoholic solution of phenolphthalein).
d) Titrate to the first definite and relatively permanent shade of pink, using N/10 sodium hydroxide.
e) The ml. of N/10 sodium hydroxide are multiplied by 0.1 to express the result as per cent acidity.

Sour cream

In creameries where high-acid cream is being tested for the purpose of standardizing the acidity, it is more exact to weigh a 9-g. sample and proceed as for sweet cream.

Condensed milk (unsweetened) [5]

a) Measure 9 ml. into a white cup.
b) Add enough distilled water, used to rinse the pipet, to restore the sample approximately to the concentration of the original milk.
c) Add indicator (1% phenolphthalein solution) at the rate of three or four drops to every 9 ml. of mixture, and titrate with N/10 sodium hydroxide to the first definite and permanent shade of pink.
d) Multiply the titer by 0.1 to express it as per cent acidity.

Ice cream mix [5]

a) The sample should first be warmed to room temperature, to eliminate the high viscosity that may be encountered.
b) Measure 9 ml. of the warmed mix into a white cup.
c) Rinse the pipet with one filling of distilled water.
d) Add six to eight drops of indicator (1% alcoholic phenolphthalein solution) and titrate to the first definite and relatively permanent shade of pink.
e) The ml. of N/10 sodium hydroxide solution used in this titration are converted into per cent acidity by multiplying by 0.1.

[5] When products such as cream, condensed milk, and ice cream mix are very viscous, it is more accurate to weigh out 9 g. of the sample than to use a pipet. With ice cream mix, however, the amount of added water must be adjusted to bring the serum solids down to from 8 to 9%.

Chocolate milk

1. The modified spot-plate test:

a) Warm the chocolate-milk sample to room temperature.
b) Use 9 g. of sample, 2 vol. of water.
c) After each addition of N/10 sodium hydroxide, stir and remove two drops of the mixture with the stirring rod and transfer to each of two depressions in a spot plate. Use one spot for a control and the other for comparison.
d) To the second spot add one drop of phenolphthalein indicator.
e) The first appearance of a faint pink color is the end-point for the mixture.
f) Report the results as percentage of lactic acid by multiplying the ml. of N/10 sodium hydroxide used by 0.1.

2. The centrifuge test:

a) Warm the chocolate-milk sample to room temperature.
b) Measure 9 ml. of the sample into a glass test-tube 115 mm. in length and 21 mm. in diameter.
c) Add 9 ml. of water at from 70 to 90° F. Mix thoroughly.
d) Fit the tube into a rubber stopper, so that the test-tube can be placed in a pocket of a Babcock tester.
e) Centrifuge the milk for 8 min. without heat.
f) Add 0.2 ml. of 1% phenolphthalein and titrate to the end-point, being careful not to disturb the precipitated fiber in the bottom of the tube. Use a stirring rod with a pitched end.
g) Report the results as percentage of lactic acid by multiplying the ml. of N/10 sodium hydroxide used by 0.1.

The modified spot-plate test gives consistent results and is a relatively simple test to perform, with only a minimum of equipment being necessary.

The centrifuge test gives a high degree of accuracy and replicability and is the best one to use. It requires more equipment and time to perform than the modified spot-plate test, but the necessary equipment is always available in a dairy testing laboratory.

TECHNICAL NOTES

MODIFICATION OF THE METHOD OF SAFFRAN AND DENSTEDT FOR CITRATE IN MILK [1]

A number of chemical methods has been reported in the literature for the determination of citric acid in biological fluids. Allen *(1)* and Heinemann *(3)* have reviewed those chemical methods used for the determination of citric acid in milk. They are all laborious, and lacking in sensitivity for use in routine work.

In recent years, rapid colorimetric methods have been developed for the estimation of small amounts of citric acid in biological fluids. Some of these methods use acetone dicarbolic acid or pentabrom acetone as a basis for color development. These, too, are laborious and unsuitable for rapid tests.

Saffran and Denstedt *(7)* developed a rapid colorimetric method for the determination of citric acid in blood. The method is based on the yellow color which develops when a deproteinized sample containing citric acid is heated with a mixture of acetic anhydride and pyridine (Furth-Hermann reaction). Babad and Shtrikman *(2)* modified this method for estimation of citric acid in milk and milk products. Rose *(5)* made a further modification of the Saffran and Denstedt method for the determination of citric acid in milk.

In a study of the chemical composition of milk *(4)*, a rapid method was needed for the estimation of citric acid. The method of Babad and Shtrikman, which seemed to be the most rapid, was tried. However, the results were considered unsatisfactory, because of the large variations between triplicates of samples (up to 16%).

Experiments with Rose's method gave sufficiently accurate results for duplicates and a satisfactory reproducibility. This method, however, was found to be very uncertain because of the violent reactions which often occurred when the samples were heated. It was found, however, that the violent reactions did not occur if the hydrochloric acid concentration in the samples was reduced from 0.1 *N* to 0.05 *N*. With the lower HCl concentration in the samples, the intensity of the developed color was somewhat lower; however, the uniformity of the color was not altered and it was still strong enough for accurate measurements.

Method

The deproteinized milk serum for the determination of citric acid was prepared according to Rowland's *(6)* procedure for the determination of proteose-peptone nitrogen. Ten ml. of the filtrate was diluted with 0.1 *N* hydrochloric acid 1:1. Thus, the sample was in 0.05 *N* HCl.

Analytical-grade citric acid monohydrate was dried over calcium chloride. Twenty g. of the dried material was dissolved in distilled water and made up to 500 ml. This stock solution was stored at 0° C. and used for several months. For use, the stock solution was diluted 1:25 and 0, 4, 5, and 6 ml., or other desired aliquots of the dilution were pipetted into 100-ml. volumetric flasks. Ten ml. of 0.5 *N* HCl was added to each flask and with distilled water made up to the mark. Solutions with 0, 64, 80, and 96 meg/ml or other known quantities of citric acid in 0.05 *N* HCl were thus obtained.

One ml. of each standard solution and of each sample was pipetted into duplicate (150 by 18 mm.) test-tubes. Then, noting the time, 8 ml. of dry analytical-grade acetic anhydride were added from an automatic buret to the first tube. The tube was stoppered loosely to allow the escape of air, agitated vigorously, and placed in a water-bath at 60° ± 1° C. The remaining tubes were treated similarly at ½-min. intervals. After 15 min., the first tube was taken out from the water bath, 1 ml. of analytical-grade dry pyridine added, the tube stoppered firmly, agitated vigorously, and placed back into the water-bath. The remaining tubes were treated similarly, in the same order, at ½-min. intervals. Forty min. after adding pyridine to the first tube, it was transferred from the 60° ± 1° C. water bath to an ice water bath. The remaining tubes were transferred similarly at ½-min. intervals. The cooling was continued for about 5 min. after the last tube entered the cold bath. Then the tubes were placed at room temperature for from 5 to 10 min. The contents of a tube were transferred with a pipette into a spectrophotometer cell or a colorimeter tube for the measurement of color. The apparatus was set with a zero standard. The optical density of the color was measured at 420 mμ. Two or three standards were run simultaneously with the unknown samples, for calculation of the results. (The standards should have citric acid contents close to the expected citric acid contents of the unknown sample.)

Results and Discussion

The uniformity of the color development and the reproducibility of the results were studied on samples of standard citric acid solutions. From three standard stock solutions a total of 100 dilutions was made, and the citric acid content of these solutions was determined in duplicate samples. The intensity of the developed color was measured at 420 mμ with a Beckman Model DU Spectrophotometer. The results of these measurements are summarized (Table 1).

[1] This investigation was supported by funds provided by the Canada Department of Agriculture.

TABLE 1

Optical density of citric acid standard solution

Samples	Citric Acid in sample	Optical density						Standard deviation	
		Individual samples			Trials Means of duplicates			Between duplicates	Between trials
(No.)	*(mcg.)*	*(min.)*	*(max.)*	*(mean)*	*(min.)*	*(max.)*	*(mean)*		
40	80	0.119	0.130	0.1241	0.1205	0.1285	0.1241	$\pm 0.0027 = (\pm 2.18\%)$	$\pm 0.0024 = (\pm 1.94\%)$
40	96	0.140	0.152	0.146	0.141	0.151	0.146	$\pm 0.0032 = (\pm 2.19\%)$	$\pm 0.0025 = (\pm 1.71\%)$
20	112	0.164	0.178	0.1692	0.1645	0.177	0.1692	$\pm 0.0031 = (\pm 1.83\%)$	$\pm 0.0029 = (\pm 1.71\%)$

It can be seen that there are some differences in the color intensity between duplicate samples and also between different trials. In 95% of the cases, however, the differences can be expected to be less than $\pm 5\%$, which is satisfactory for colorimetric determinations.

The reproducibility of the determinations in milk was studied on two milk samples. From each of these samples, ten separate serums were prepared and the determinations made in four separate trials. Results of these determinations are summarized (Table 2), and show that the reproducibility was very good. The average variation was less than 1%.

The accuracy of the recovery of the method was examined by adding known quantities of citric acid to 14 samples of milk serum. The recovery was from 95.3 to 100.4% and averaged $98.04 \pm 2.08\%$. These results, and the results of the reproducibility tests, show that the method can be used for the estimation of citric acid in milk.

For best results with this method, the following points should be observed:

The heating of the samples should be done in such a manner that the upper ends of the tubes and the stoppers are dry when pyridine is added. Otherwise, water may get into the test-tube and influence the development of the color.

Rubber stoppers, when heated with acetic anhydride or pyridine, show traces of color which influence the intensity of the color of the sample, if they are allowed to come in contact with the mixture in the tube. Therefore, mixing of the samples should be done in such a manner that the upper parts of the tubes and the stoppers are moistened as little as possible with the mixture in the tubes.

TABLE 2

Reproducibility of citric acid determination in milk

(Five determinations made in each trial)

Trial No.	Citric Acid found Range	Av.	Coefficient of variation
			(%)
1	87.4-89.3	88.5 ± 0.656	0.74
2	87.0-89.6	88.3 ± 0.900	1.02
3	95.7-97.0	96.4 ± 0.548	0.57
4	94.4-97.0	96.2 ± 1.039	1.08

A. REINART
J. M. NESBITT
University of Manitoba, Winnipeg, Canada

REFERENCES

(1) ALLEN, L. A. Mineral Constituents and Citric Acid Content of Milk. *J. Dairy Research*, 3: 1. 1931.

(2) BABAD, I., AND SHTRIKMAN, N. The Estimation of Citric Acid in Dairy Products. *J. Dairy Research*, 18: 72. 1951.

(3) HEINEMANN, B. The Determination of Citric Acid in Milk Products by Cerate Oxidimetry. *J. Dairy Sci.*, 27: 377. 1944.

(4) REINART, A., AND NESBITT, J. M. The Composition of Milk in Manitoba. Proc. XIVth Intern. Dairy Congr., Rome, 1956. Vol. 1, Pt. II, p. 946.

(5) ROSE, D. Food Chemistry Section, Division of Applied Biology, National Research Council, Ottawa. Private communication, 1954.

(6) ROWLAND, S. J. The Determination of the Nitrogen Distribution in Milk. *J. Dairy Research*, 9: 42. 1938.

(7) SAFFRAN, M., AND DENSTEDT, O. F. A Rapid Method for the Determination of Citric Acid. *J. Biol. Chem.*, 175: 849. 1948.

A BEAKER TEST FOR ESTIMATING GAS-PRODUCING TENDENCY OF LACTIC ACID–STARTER CULTURES [1]

Frequent difficulty in recent years with a defect of cottage cheese known as floating curd led to a study of gas production by lactic streptococcus–starter cultures used for manufacture of this product. Investigation demonstrated that most instances of the defect were related to the presence in the mixed-strain starter cultures of lactic acid streptococci ca-

[1] Technical Paper No. 1068, Oregon Agricultural Experiment Station. Contribution of the Departments of Bacteriology and Food and Dairy Technology.

pable of producing excessive quantities of CO_2 *(3)*. In fact, great differences were found to exist in CO_2 production by different cultures.

Four types of single-strain streptococci, as characterized by activity (rate of acid production) and CO_2 production, were isolated from high gas–producing, mixed-strain cultures. These could be classified generally as follows: high acid–high gas, low acid–high gas, high acid–low gas, and low acid–low gas. Single-strain isolates obtained from low gas–producing, mixed-strain, lactic acid cultures included only the latter two types. This indicated that the high CO_2-producing strains either were absent, or were present in low numbers, in such mixed-strain cultures.

One desirable characteristic of the high CO_2-producing lactic streptococci is their high butter-aroma production, as evidenced both by flavor of cultures and by tests by the King method for acetyl-methylcarbinol plus diacetyl *(1)*. This might favor their use in cultures employed for buttermilk or for cultured cream. However, the use of cultures with different CO_2-producing abilities contributes to variation in finished cottage cheese, which makes it difficult to market a product with uniform body and flavor from day to day. Whey retention, curd shattering, and curd matting have been the most important defects noted in the finished cheese made with gassy starter cultures.

It is possible that some of the mixed-strain, lactic acid–starter cultures available to dairy manufacturers are composed of both high and low gas–producing strains of streptococci. Nichols and Ineson *(2)* have indicated that certain strains in a mixed-strain culture become dominant on prolonged daily transfer. If such is the case, it is logical to assume that this factor may, under certain circumstances, result in a high CO_2-producing, mixed-strain culture. The volume of CO_2 produced by mixed-strain cultures appears to be fairly constant from day to day, under uniform culturing conditions. However, variations in temperature of incubation, length of incubation period, amount of inoculum, and type of treatment of culture medium may be expected to alter gas production by a mixed-strain culture. For example, underripening of gas-producing, mixed-strain starter cultures has resulted in a certain degree of control of the floating curd defect in some cottage cheese plants. However, the same plants have encountered difficulty with excess gas production and floating curd when the culture handler inadvertently left such cultures in the incubator for longer than normal periods for one or two transfers.

A more basic approach to the problem may eliminate the necessity for concern with such factors as strain dominance and minor variations in culture handling. By combining nongas–producing lactic acid streptococci and compatible nongas–producing associative flavor organisms, mixed-strain cultures may be developed that exhibit excellent flavor characteristics and show no high CO_2-producing tendencies *(3)*. Such cultures should eliminate the floating curd defect of cottage cheese and provide the consumer with a more uniform product. Evidence that such cultures may overcome some of the difficulty encountered with open texture in Cheddar cheese manufacture is also present.

A simple gasometer apparatus, which enables the cheese manufacturer to eliminate the high gas-producing starter cultures from his operation, has been developed *(4)*. This test has been employed successfully under both plant and laboratory conditions, to eliminate the floating curd defect. Further investigation has developed a beaker test which has the advantage of greater simplicity than manometer and gasometer devices in examination of cultures for CO_2 production. Following is a description of the procedure, together with results obtained with this method.

Experimental Methods

Low-heat, nonfat, dry milk solids were reconstituted to a volume of 800 ml. at 12% solids and placed in 1,000-ml. beakers. The beakers were covered with aluminum foil and pasteurized at 61.7° C. (143° F.) for 30 min. Pasteurization minimized the possibility of gas production from contaminants in the dry milk solids or water supply. After cooling to 30° C. (86° F.), the milk was inoculated with 5% of the culture in question and placed in a water-bath maintained at this same temperature. After one hour, 0.6 ml. of a 1:10 dilution of cottage cheese coagulator was added and the incubation continued until a whey acidity of 0.6% was reached.

The curd was then cut into vertical squares by pushing a disc of galvanized wire screen through the curd to the bottom of the beaker (this disc was about 9.5 cm. in diameter and divided into 1-cm. squares). Horizontal cutting was completed by passing a single wire, 9.5 cm. in length, in a circular manner through the curd in the beaker. The wire was attached for this purpose to the ends of two aluminum rods and was lowered about 1 to 1.5 cm. after each turn. Any apparatus that would cut the curd uniformly into small particles should be suitable for this purpose. Gentle stirring was begun, following cutting of the curd, and the cooking process was initiated. Heat was gradually applied so that a temperature of 49° C. (120° F.) was reached in about 45 min. This was accomplished in the thermostatically controlled water-bath by turning the control dial to maximum setting until the desired temperature was reached (about 45 min.). Any modification of such equipment that will bring the contents of the beaker to 49° C. (120° F.) should prove satisfactory for this step. The

screen disc used to cut the curd vertically was withdrawn by tweezers as soon as the curd was sufficiently firm to prevent shattering (in about 20 to 25 min.).

Throughout the cooking and stirring process, observations were made of: *(a)* the floating and matting tendency of the curd, *(b)* appearance of gas bubbles in the whey, and *(c)* the collection of foam on the surface of the whey in the beaker.

Results and Discussion

Lactic acid–starter cultures which had been carefully examined for CO_2 production, and classified as low, medium, high, or very high in this regard, were tested by the beaker method described. A description of each of the cultures, listed as to type and source, may be obtained by referring to an earlier report *(3)*. Results are presented (Table 1).

The differences observed in all cases between low and very high gas-producing cultures with this test were striking. The photograph shown (Figure 1) is typical of the many tests that were run comparing these two types. Results indicate that the beaker test can be used to identify many lactic acid–starter cultures that cause the floating curd defect during cottage cheese manufacture.

TABLE 1

Relationship between gas production and results of beaker test on single- and mixed-strain lactic starter cultures

Culture	Gas rating [a]	Appearance of curd and whey after cutting
2R	Low	Cultures showed no evidence of gas production during the beaker test. The curd settled immediately after cutting and the whey was a clear yellow color, because of the absence of gas bubbles. No foam formation could be induced, even with severe stirring.
8D	Low	
17D	Low	
19	Low	
20	Low	
21	Low	
24	Low	
28	Low	
29	Low	
S1E	Low	
1R	Low	Cultures showed gas bubbles after cutting, and also a tendency to float, accompanied by some foam. However, the curd settled during the cooking.
18	Medium	
25	Low	
3-R	Very high	These cultures showed immediate appearance of gas bubbles in the whey at cutting. The curd floated to the top when heated and showed a tendency to mat. Stirring the curd with sufficient force to keep the curd from clumping caused severe foaming.
4R	Very high	
4R-5	Very high	
6B	Very high	
7B	Very high	
23	Very high	
26	Very high	
27	Very high	
30	Very high	
33	High	

[a] Based on laboratory gasometer test *(4)*.

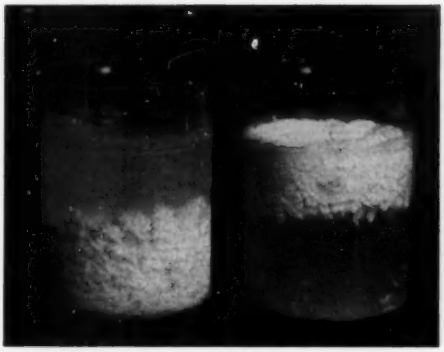

FIG. 1. Results with the beaker test using low gas-producing mixed-strain culture 2R (left) and high gas-producing mixed-strain culture 33 (right).

W. E. SANDINE
P. R. ELLIKER
G. H. WILSTER
R. L. STEIN
A. W. ANDERSON
Departments of Bacteriology and Food and Dairy Technology, Oregon Agricultural Experiment Station, Corvallis

REFERENCES

(1) KING, N. A Modification of the Voges-Proskauer Test for Rapid Colorimetric Determination of Acetylmethylcarbinol Plus Diacetyl in the Butter Cultures. *Dairy Inds.*, 13: 860. 1948.

(2) NICHOLS, A. A., AND INESON, P. J. Cheese Starter Recovery After Attack by Bacteriophage. (Strain Dominance in Multiple Strain Starters.) *J. Dairy Research*, 15: 99. 1947.

(3) SANDINE, W. E., ANDERSON, A. W., AND ELLIKER, P. R. How to Avoid "Floating Curd" when Making Cottage Cheese. *Food Eng.*, 29(1): 84. 1957.

(4) SANDINE, W. E., ELLIKER, P. R., AND ANDERSON, A. W. A Simple Apparatus for Measurement of Gas Production and Activity of Lactic Starter Cultures. *Milk Prod. J.*, 48(1): 12. 1957.

PHOSPHATASE REACTIVATION IN HIGH-TEMPERATURE, SHORT-TIME PASTEURIZED CREAM

In a recent publication *(1)*, it was reported that reactivation of the phosphatase enzyme occurred in commercially pasteurized cream when the cream sample was held at room temperatures for short periods of time following pasteurization. Some criticism of this work has been received because the phosphatase determinations were reported qualitatively, using the Scharer Rapid Method *(3)*, as supplied by Applied Research Institute. The suggestion was made that a cream sample which showed zero phosphatase immediately after pasteurization by the official AOAC Sanders-Sager Method *(2)* might not show reactivation, regardless of the pasteurization treatment or storage conditions.

Some confirmatory experiments were conducted with 20% cream, pasteurized in a small tubular heater for 16 sec. at 165, 180, and 210° F. Phosphatase determinations immediately after pasteurization, and after storage at various temperatures, were made using the Sanders-Sager AOAC method and, in some cases, the Scharer Rapid Method. In each case, a raw cream sample, made from boiled cream with 0.1% raw cream, and a boiled sample, served as controls.

Data showing the effect of storage time following pasteurization, on the reactivation of phosphatase in HTST cream, is presented (Table 1). These results indicate increasing amounts of reactivated phosphatase in the cream samples as the pasteurization temperature and storage time were increased.

TABLE 1

Phosphatase activity in 20% HTST pasteurized cream after storage at 88° F.

Pasteurization treatment	Phosphatase—μg phenol/ml		
	Initially	After 2 hr. at 88° F.	After 4 hr. at 88° F.
165° F/16 sec.	0	1.2	6.3
180° F/16 sec.	0	6.6	16.8
210° F/16 sec.	0	9.6	21.6
Raw cream	3.8	....	.....

The effect of storage temperature on the amount of phosphatase reactivation in HTST cream pasteurized at 180° F. for 16 sec. is summarized (Table 2). At 60° F., after 5 hr., only slight reactivation of the enzyme was observed; whereas, at 88° F. after this same time, considerable reactivated phosphatase was found. When these samples were stored at 50° F. or below for as long as five days, no reactivated phosphatase was found in the cream.

TABLE 2

Phosphatase activity in 20% cream pasteurized at 180° F. for 16 seconds and stored 5 hours at various temperatures

Storage temperature	Phosphatase—μg phenol/ml
88° F.	21.6
70° F.	10.8
60° F.	2.4

Additional samples of 20% cream, HTST pasteurized at 180° F. for 16 sec., were again stored at three different temperatures following pasteurization, and examined for phosphatase both by the Sanders-Sager and by the Scharer Method. These results (summarized in Table 3) indicate that the Scharer Rapid Method is quite sensitive in detecting low levels of phosphatase in 20% cream. The Sanders-Sager values reported for the samples stored at 60 and 70° F. are lower than the suggested 4 μg. phenol/ml standard for cream and would, therefore, not be reported as positive phosphatase. With the Scharer test, however, these samples showed definite blue color and would, consequently, be reported as being improperly pasteurized.

TABLE 3

Phosphatase activity in 20% cream pasteurized at 180° F. for 16 seconds and stored for one and one-half hours at various temperatures

Cream sample	Storage temperature	Phosphatase activity	
		Sanders-Sager μg phenol/ml	Scharer Rapid Method
HTST cream	88° F.	5.5	Strong +
HTST cream	70° F.	2.0	Definite +
HTST cream	60° F.	1.0	Slight +
Raw cream	.....	5.0	Strong +
Boiled cream	.....	0.0	Negative

HARVEY FRAM
Research Laboratories Division
National Dairy Product Corporation
Oakdale, Long Island, New York

REFERENCES

(1) FRAM, H. The Reactivation of Phosphatase in HTST Dairy Products. *J. Dairy Sci.*, 40: 19. 1957.
(2) SANDERS, G. P. Report on the Phosphatase Test in Pasteurization of Dairy Products. *J. Assoc. Offic. Agr. Chem.*, 31: 306. 1948.
(3) SCHARER, H. A Rapid Phosphomonoesterase Test for Control of Dairy Pasteurization. *J. Dairy Sci.*, 21: 21. 1938.

FERTILITY RESULTS WITH FROZEN SEMEN STORED FOR TWO YEARS [1]

Mixner and Wiggin [2] reported that in a split-ejaculate study, frozen semen from five Holstein bulls showed no significant decline in fertilizing capacity when stored for from 7 to 14 days, 6 mo., and 1 yr. at −79° C., as compared to the unfrozen control semen. The semen was frozen in an egg yolk, sodium citrate, glycerol diluter containing streptomycin. The frozen semen bank referred to in that report has now been sampled after 2 yr. of storage at −79° C., to determine again its fertilizing capacity. Frozen semen from each of the five bulls was bred to approximately 20 first-service cows for a total of 102 breedings. The mean fertility rate at this time for the five bulls, based on 30- to 60-day nonreturns was 75.5%; whereas, the 60- to 90-day nonreturn rate was 65.7% (Table 1). This same semen used fresh and after storage at −79° C. for from 7 to 14 days, 6 mo., and 1 yr. had 60- to 90-day nonreturn rates of 68.0, 66.7, 70.1, and 65.7%, respectively. These results indicate that semen may be stored for at least 2 yr. at −79° C. without causing an appreciable decline in the fertilizing capacity of the semen.

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Dairy Industry, New Brunswick.

[2] Mixner, J. P., and Wiggin, S. H. Fertility Results with Frozen Semen Stored up to One Year. *J. Dairy Sci.*, **40**: 537. 1957.

TABLE 1

Fertility of frozen semen stored for 2 yr. at −79° C.

Characteristic	Bull and semen sample					
	24H-51	H101-54	H88-60	H89-68	H103-69	Totals and means
Cows bred *(No.)*	20	21	19	22	20	102
30- to 60-day nonreturns *(%)*	60.0	80.9	89.5	68.2	80.0	75.5
60- to 90-day nonreturns *(%)*	55.0	61.9	89.5	54.5	70.0	65.7

J. P. Mixner
S. H. Wiggin [3]
New Jersey Agricultural Experiment Station and Sussex County Cooperative Breeding Association, Inc., Sussex

[3] Manager, Sussex County Cooperative Breeding Association, Inc., Sussex, New Jersey.

ERRATUM

Sato, I., Hankinson, C. L., Gould, I. A., and Armstrong, T. V. Some Factors Affecting the Freezing Point of Milk. *J. Dairy Sci.*, **40**: 410. 1957.

page 413, paragraph 2, line 2, change 0.030° C. to read 0.003° C.

page 415, paragraph 3, line 4, change −0.536° C. to −0.540° C.

page 417, Reference 10, change to read: Shipe, W. F., Dahlberg, A. C., and Herrington, B. L. Variations in the Freezing Points of Cow's Milk. *J. Dairy Sci.*, **36**:924. 1953.

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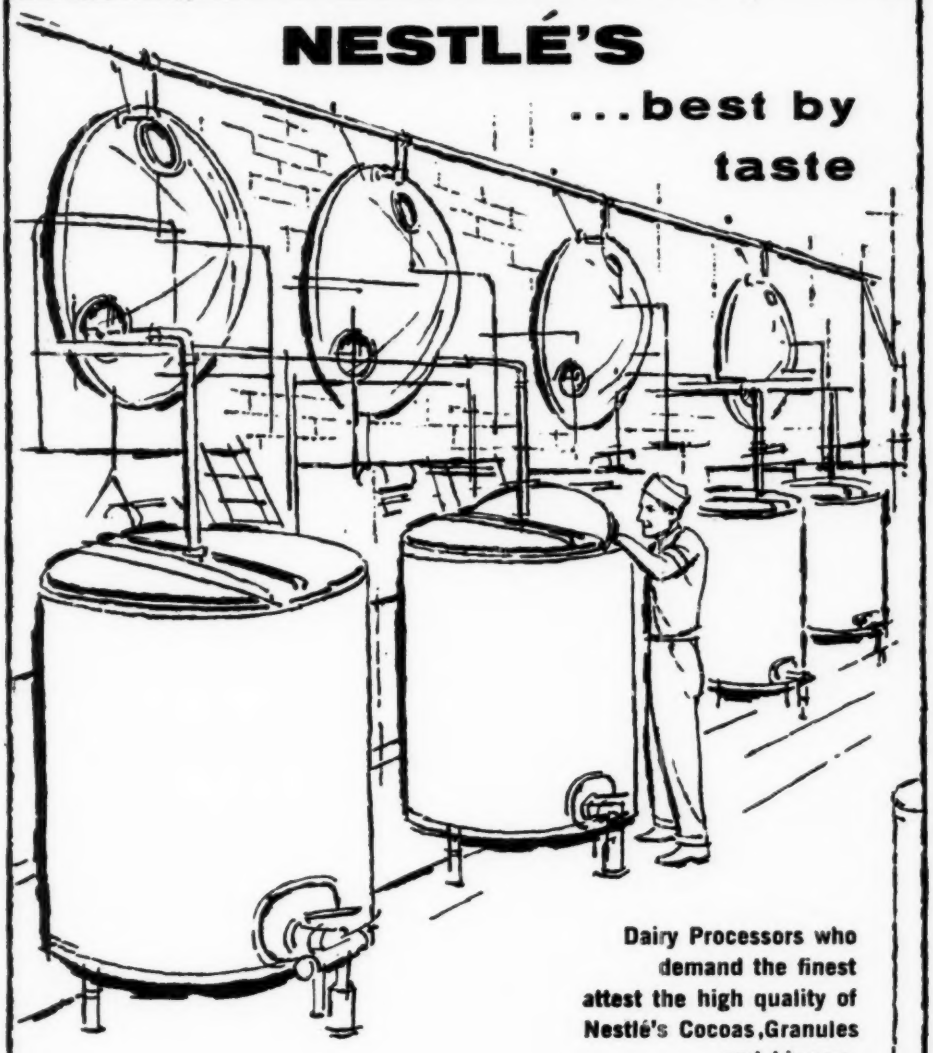

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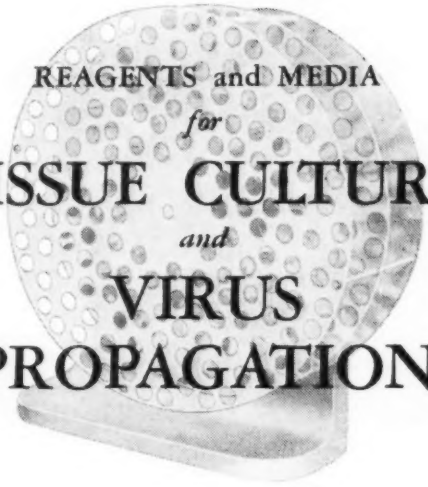

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